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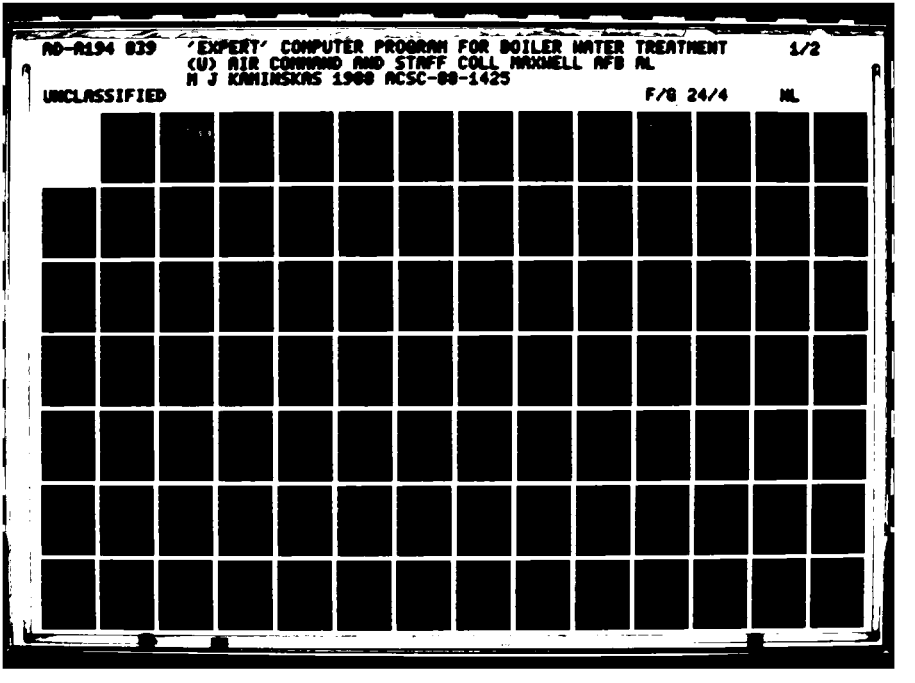

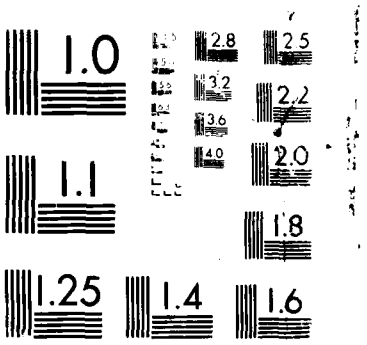

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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

"EXPERT" COMPUTER PROGRAM
FOR
BOILER WATER TREATMENT

MAJOR MICHAEL J.W. KAMINSKAS 88-1425

"insights into tomorrow"

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TITLE "EXPERT" COMPUTER PROGRAM FOR BOILER WATER TREATMENT

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AFR 91-40, Industrial Water Treatment, 24 September 1984, initiated a new era in Air Force boiler water treatment. The study evaluates the current implementation status of this regulation through associated formal schools support, central laboratory use, check analysis performance, and AFESC Corrosion Analysis Reports. The evaluation identifies a lack of expertise at base level due to lagging technology transfer. The study then investigates the development of an "expert" computer program following AFR 91-40 and AFP 91-41, Industrial Water Treatment Procedures, 18 September 1987, to improve this information transfer and bolster management emphasis. Initial validation against Maxwell AFB central energy plant data identifies problem areas confirmed by plant personnel. Using program output, the author recommends a pretreatment system and generic chemicals that have an estimated effective annual savings of $11,505. The study concludes that additional validation of the program is necessary and recommends a one-year test by graduates of AFIT's ENG 595, Industrial Water Treatment, course.

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PREFACE

This staff analysis project proposes a computer program to assist technology transfer to the civil engineering career field. The program, developed as part of this project, acts as an "expert" system in the water treatment of steam boilers. Experience has shown that poorly controlled boiler water treatment is detrimental to energy conservation, maintenance efficiency, and equipment life. Current boiler water treatment technology transfer began in 1977. Data from HQ AFESC/DEMM indicates less than full and effective implementation of boiler water treatment programs as presented in current directives. In September 1987, HQ AFESC/RDC expressed a need for further assistance in transitioning any new technology to civil engineering. This paper documents the development of the "expert" computer program and its evaluation as a technology transfer tool to improve boiler water treatment.

Copies of the software, including source code, may be obtained by writing HQ AFESC/DEMM, Tyndall AFB, Florida 34201-6001, or AFIT/DEE, Wright-Patterson AFB, Ohio 45433-5000. Requestors must supply a single 8-inch floppy disk. A copy of this staff analysis will be provided with the disk to explain the program. The software is compatible with WANG minicomputers purchased under the Air Force Buy Program for Civil Engineering and uses WANG BASIC with its system specific instructions and commands.

ACKNOWLEDGMENTS

First and foremost, I give my greatest thanks to my wife, Marie, and our three children for their patience and understanding. They gave up much during the development of this project. Lt Col Robert L. Peters, my Air Command and Staff College project advisor, has my deep gratitude for providing the needed focus as well as encouragement. Appreciation goes also to SSgt William B. Wood, 3800 ABW/LGSF, and Mr. Herbert M. Lott, 3800 ABW/DEMDP, for their special and standard testing, respectively, of boiler water samples. Finally, a big thanks to the Maxwell AFB Civil Engineering Industrial Engineering Branch, 3800 ABW/DEI, for their computer support and assistance in understanding the intricacies of the WANG computer system.

ABOUT THE AUTHOR

Major Michael J.W. Kaminskas graduated from Lehigh University in 1972, receiving a Bachelor of Science degree in Electrical Engineering. Commissioned in 1974 through ROTC while also doing graduate work at Lehigh, he entered active duty as a civil engineering officer at Carswell AFB, TX. There he learned the rudiments of cathodic protection of underground utilities and water tank interiors and took the Air Force Institute of Technology (AFIT) Corrosion Control Course. Selected in 1978 for the AFIT Education with Industry Program as a field chemist with the Illinois State Water Survey, Champaign, IL, he familiarized himself with the future Air Force water treatment technology. Next, a tour at HQ Air Force Engineering and Services Center, Tyndall AFB, FL, included a one-year assignment as the Chief, Corrosion Analysis Team. This traveling team analyzes the cathodic protection, water treatment, and protective coatings at bases world-wide. Selected for graduate work under the Senior Commanders' Education Program, he chose Rensselaer Polytechnic Institute, Troy, NY, and received a Master's of Engineering degree in Electric Power Engineering in 1982. His assignment to the AFIT School of Civil Engineering at Wright-Patterson AFB, OH, used his electrical and corrosion backgrounds. He ended his four-year tour there as Chief, Electrical Section and Assistant Professor of Electrical Engineering and Industrial Water Treatment. A remote tour as the Base Civil Engineer at Shemya AFB, AK, transitioned Major Kaminskas into his current assignment as member of the Air Command and Staff College (ACSC) class of 1988. Squadron Officers School in residence and ACSC by seminar round out his professional military education background.

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EXECUTIVE SUMMARY

Part of our College mission is distribution of the students' problem solving products to DOD sponsors and other interested agencies to enhance insight into contemporary, defense related issues. While the College has accepted this product as meeting academic requirements for graduation, the views and opinions expressed or implied are solely those of the author and should not be construed as carrying official sanction.

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REPORT NUMBER 88-1425

AUTHOR(S) MAJOR MICHAEL J. W. KAMINSKAS, USAF

TITLE "EXPERT" COMPUTER PROGRAM FOR BOILER WATER TREATMENT

I. Purpose: To investigate the development of an "expert" computer program that will improve technology transfer and bolster management emphasis in the area of boiler water treatment. The program follows the basic requirements of AFR 91-40, Industrial Water Treatment, and AFP 91-41, Industrial Water Treatment Procedures, as well as attempting to go beyond the calculations presented in AFP 91-41 in order to predict the final system operating point after all chemical addition.

II. Problem: Since the publication of AFR 91-40 in September 1984, there has been limited improvement in base-level boiler water treatment. Recurring areas of concern are the extent of expertise and management emphasis at base level. Often these result in acquiring expertise through the purchase of expensive proprietary chemicals and operating Air Force steam systems at less than optimum efficiency.

III. Data: Formal schools are the Air Force's primary means for technology transfer. However, at current rates it will take over five years to provide the minimum number of short course graduate

engineers and technicians needed. AFESC Corrosion Analysis Reports and AFIT on-site seminar trip reports since September 1984 confirm the limited implementation of AFR 91-40 and the extensive use of proprietary chemicals. A bright spot is the use of the central laboratory set up by AFESC to standardize chemical testing Air Force-wide. However, the check analysis program run by the laboratory indicates that overall testing accuracy is poor with over 50 percent of the results missing the target value by more than 30 percent. The computer program seeks to computerize the calculations for boiler water treatment in AFP 91-41, analyze equipment parameters for proper operation and print warnings if out of tolerance, predict the final boiler operating point after chemical addition, and use the operating point prediction to analyze the current treatment. The operating point prediction allows comparison of system and treatment changes, providing sufficient data output to perform an economic analysis.

Validation of the program against Maxwell AFB central energy plant data resulted in the confirmation of system operation problems already noted by plant personnel. Using the program to compare changes allowed the author to recommend a new pretreatment system that generates an estimated $11,505 in effective annual savings. The base placed this recommended pretreatment system under design for construction in the near future. Unfortunately, the prediction of boiler chemical levels at the final operating point did not correlate with actual levels when the program was constrained to model actual operation.

IV. Conclusions: The computer program improves understanding of AFP 91-41 procedures and saves many hours of computation by hand calculator. Also, gathering data required for program input increases the interaction between plant, engineering, and management personnel. In its current form the program is not sufficiently "expert" to replace formal schools. For example, decision trees were large to analyze system problems, but the warnings produced were general in nature. To generate specific and detailed warnings will require very extensive decision trees. Thus, the current program still requires expertise to operate and evaluate output.

V. Recommendations: Using data from just one base is inadequate to fully validate this computer program. Limiting initial distribution of the program to major command industrial water treatment engineers and graduates of the AFIT industrial water treatment course places the program with those who have sufficient expertise. A one year application test with feedback to AFESC/DEMM and AFIT/DEE will expand the validation data base and allow AFESC to decide on future distribution.

Chapter One

INTRODUCTION

The Air Force Civil Engineering Corrosion Control Program administered by the Air Force Engineering and Services Center (AFESC) received a Functional Management Inspection by the Air Force Inspection and Safety Center in 1978. One finding of the inspection stated that guidance in the form of regulations, manuals, and pamphlets was out-of-date, in some cases not being changed in over 15 years, although updates were in various states of completion. Further, this was a contributing factor in the lack of base-level corrosion control program effectiveness. (11:--) Within the next six years every corrosion publication received a thorough review and underwent republishing. This project focuses on the industrial water treatment (IWT) component of corrosion control. It specifically looks at the current implementation of boiler water treatment directives and investigates a new technique to improve this implementation.

WHY TREATMENT?

There are some 151 major and minor active duty Air Force installations around the world. These installations use steam from boilers to heat buildings and domestic hot water, cook food, clean clothing, humidify computers and hospital operating rooms, generate electricity, clean aircraft and vehicles, operate the gym's steam room, and even provide air conditioning. The steam systems require funds for construction, operation, and maintenance.

Air Staff figures from FY 86 Air Force real property records indicate a capital investment of $606.6 million for large central heating plants over 750,000 British thermal units in size. Operation of these systems cost $164.4 million in FY 86, with fuel going an additional $128 million that same year. Maintenance in FY 86 ran another $52.5 million. (21:--) When distribution piping, auxiliary equipment in outlying buildings, and smaller boilers are included, the author estimates a capital investment of at least double this figure, with an associated additional cost for operation, maintenance, and fuel.

"Industrial water is treated to prevent scale and corrosion, increase efficiency, prolong life, and reduce repair and

replacement of water-using equipment." (14:1) In 1979, AFESC estimated the corrosion losses due to inadequate water treatment for all industrial water systems (not just boilers) at $180 million per year. (17:1) Thus, boiler water treatment has a significant effect in keeping our base utilities functioning in an efficient and cost effective manner.

The starting point for water treatment is the source of water, which may be a potable or nonpotable supply. The supply's water quality varies between every point on the globe, between seasons of the year, and between the sources of supply--well, river, lake, or any combination of these. In fact, the water quality may fluctuate minute to minute as two different sources are mixed to meet the demand. What makes a good potable water usually makes a poor boiler water. Therefore, boiler water treatment seeks an optimum water quality for boiler use.

The treatment requires a balance of several economic decisions. Specialized equipment or regulated chemical addition can be used separately or together to achieve effective boiler water treatment. Usually, mechanical means using specialized equipment backed up by chemical addition are more cost effective than using chemicals alone. The goal is to keep the boiler clean of scale and free of corrosion so as to ensure efficient heat transfer and long equipment life. Metering, chemical testing, and proper system operation are also an important part. When integrated with these areas, boiler treatment can result in maximum energy conservation, lengthened equipment life throughout the steam system, minimum water use, and the potential elimination of crisis maintenance. Without boiler water treatment you can expect waste of resources and abuse of the equipment.

The total integration of water treatment and testing into the complete system operation and vice versa is the final answer. In this way any malfunction of system equipment or operation can be detected by chemical testing with sufficient early warning to allow speedy repairs. Conversely, water treatment prevents system malfunctions from causing additional damage through corrosion or scale. Thus, the relationship between steam system operation and boiler water treatment is mutually beneficial.

CURRENT STATUS

Prior to AFR 91-40, Industrial Water Treatment, 24 September 1984, the Air Force had been using a boiler treatment program developed and supported by the US Bureau of Mines (BOM). The regulation changes affecting boiler water treatment included

1. new testing philosophy modeled after the successful program at the Illinois State Water Survey,

2. conversion of central laboratory support from the BOM to a commercial laboratory under contract to AFESC,
3. a revised quality control program modeled on the Environmental Protection Agency certified laboratory concept, and
4. the federal stock listing of all bulk chemicals needed for boiler water treatment.

While these changes may seem extensive, experienced base-level personnel would have little difficulty in transitioning. But, experience is in limited quantity at base level, and the initial method to gain experience is through education of engineers and training of technicians.

The AFIT School of Civil Engineering and Services (SOCES) received a draft of AFR 91-40 in January 1984 and incorporated it into the first course offering of ENG 595, Industrial Water Treatment, the next month. This course reached a total of 109 engineers and selected technicians, according to AFIT/DES figures, with two offerings each in FYs 84 and 85 and one offering each in FYs 87 and 88. Budget restrictions and priorities deleted the FY 86 offering. The graduates represent 59 installations world-wide. While AFIT SOCES can respond quickly to the career field's needs, only 36 percent of installations have taken advantage of ENG 595. Graduates that have been able to apply this education have very successful industrial water treatment programs. Wright-Patterson and Robins AFBs come first to the author's recollection. While AFIT SOCES focuses on managers and engineers during in-house courses, the school's on-site seminar experience repeatedly demonstrated that technology transfer had the greatest success when managers, engineers, and technicians received information commensurate with their needs. The training of technicians is equally important to the success of a program.

The Sheppard Technical Training Center, Sheppard AFB, TX, also received a draft of AFR 91-40 in early 1984. From FY 84 through the first half of FY 87, Course J3AZR54552 000, Boiler Water Treatment and Corrosion Control, offered technician training according to the old BOM procedures. In April 1987, Course J3AZR54552 001, Mechanical Systems Water Treatment, came on line and covers boiler water and cooling tower treatment per AFR 91-40. The two and one-half year time lag from publication of the new regulation to the first updated course offering can be attributed to many factors. First is the Air Training Command (ATC) procedure for making any changes to an established course, which includes ATC review of the changes. Secondly, as this course directly affects promotion testing, the appropriate career development courses and promotion tests had to be implemented simultaneously. Lastly, the design of ATC instruction material allows the most inexperienced instructor to meet all objectives.

These actions require much time to implement and this time lag directly affects the primary means of technology transfer to technicians.

HQ ATC figures from 1Lt Peter Cappello, Training Systems Programmer, DCS/Technical Training, show 363 technicians receiving training under the old course from FY 84 to FY 87. A training evaluation report covering November 1985 through November 1986 listed 68 percent of the 55 respondents rating the course marginal or unsatisfactory due to the outdated information presented in the course. (12:i) In FY 87, 68 technicians took the old course and the first updated offering trained 16 technicians from as many bases. The Trained Personnel Requirement for FY 87 was 155 (12:1), leaving 87 slots for the new course. Considering two personnel per base minimum (one boiler and one refrigeration technician), it will take another year and a half to transfer current IWT technology to each installation. Thus, minimum technology transfer occurs over five years after the publication of the regulation.

Fortunately, the current regulation and pamphlet are easy to read as the original authors specifically targeted the technicians. (22:--) With guidance, education, and training under way, AFESC has also standardized IWT world-wide through a central laboratory contract.

The central laboratory concept improved implementation of the new regulation by supplying standardized test kits and chemical reagents to perform the prescribed testing. The base personnel need only use a request form supplied by the laboratory to receive their order within two weeks world-wide. All costs are borne by the AFESC contract. This is most beneficial in getting capability to a base in a timely manner. For example, chemical reagents have a shelf life of six months to one year. While at Shemya AFB, the author identified a contractor at a radar facility using essentially the same testing procedures and chemicals as available from the central laboratory. However, many of their reagents were out-of-date since base supply maintained a double-order backup due to its remote location. Conversion to supply through the central laboratory will ensure chemical freshness and constant testing capability. Regardless of the obvious benefits, only 103 installations have taken advantage of this service since its inception in FY 85. Of these bases, 92 percent show consistent usage rates. The central laboratory also supports a check analysis program.

The check analysis program is the outgrowth of an AFIT master's degree thesis submitted in September 1983 by Capt Dennis C. Hughes. Capt Hughes challenged the effectiveness of the BOM check analysis program in which boiler samples were sent to the BOM laboratory for analysis by the same techniques as used at base level. Transportation time and lack of sample preservation

caused consistently inaccurate test results. Base-level management received little substance from this information. Capt Hughes recommended a program along Environmental Protection Agency lines. A preserved sample is sent to the installation, base personnel regularly engaged in testing then use standard IWT procedures to test the sample, and the results are mailed to the central laboratory. The laboratory compares the results to control tests taken on the same sample batch on the same day the base tested their sample. The laboratory sends the interpretation to the base, the major command, and AFESC. This is an excellent quality control measure that highlights poor testing techniques and deteriorated reagents. (9:14)

Nonparticipation in the check analysis program varied from 51 installations in FY 85 to 29 in FY 87, according to records provided by AFESC/DEMM. The central laboratory sent out 1108 boiler water samples for FY 85 through FY 87, requiring 8864 tests to be run (8 tests per sample). The installations accomplished 6464 tests for a 72.9 percent effort, with many samples receiving only partial testing. Testing accuracy showed only slight improvement over the last three years, except for conductivity and pH, which improved 40.8 and 12.9 percent respectively from FY 85 to FY 87 for test results within 20 percent of the target. A disturbing statistic concerns the percent of results not within 30 percent of the target value. For FY 87, overall 52.8 percent of the results missed even this liberal criteria. Results of individual tests with this percent in parentheses are as follows: lignosulfonate (81.05), sulfite (61.11), hydroxyl alkalinity (43.14), phosphate (40.85), methyl orange (M) alkalinity (33.01), phenolphthalein (P) alkalinity (27.13), conductivity (18.63), and pH (8.82). These figures include tests not run on sample results reported to the central laboratory. Thus, the lignosulfonate percent indicates few bases are using lignosulfonate as a sludge conditioner. The author interprets the sulfite percent as poor sample preservation and handling, allowing atmospheric oxygen to consume the sulfite in the sample. The remaining values are a mixture of sample preservation, testing technique, and reagent purity. Thus, these statistics indicate a need for increased base-level management. There are two indicators left to complete the understanding of current status--AFIT SOCES on-site seminar trip reports and AFESC Corrosion Analysis Reports.

Since the publication of AFR 91-40, AFIT instructors have consistently identified actions during on-site seminars that could produce yearly cost savings. A major problem was the continued use of commercial water treatment companies and their expensive proprietary chemicals. (16:--) Bases tend to use these commercial firms to overcome their lack of in-house expertise, since most companies provide "free" services when you purchase their chemicals. (19:--) These services are also a quick avenue for bases to get an IWT program on line. Policy and guidance

explicitly instruct bases to develop in-house programs using generic chemicals from federal stock lists. (17:--; 13:1; 14:1) Unfortunately, once a commercial firm establishes itself, inertia at the base makes it difficult to convert to an in-house program. Other problems include the practice of repair-by-replacement in lieu of preventive maintenance, to which IWT is a strong contributor. For example, during an on-site seminar in 1986, personnel from one Korean base related to the author that their base carried small packaged boilers as expendable bench stock items. These boilers did not receive any water treatment and had a life expectancy of one to two years. AFESC Corrosion Analysis Reports tell a similar story.

The Corrosion Analysis Team published 20 reports from September 1984 to March 1987. Eighteen of the reports listed steam systems as part of the infrastructure surveyed and 11 of these used proprietary chemicals with mixed results. Sixteen reports indicated problems with steam systems that boiler water treatment can impact. The recurrent theme in the reports is the less than full use of IWT capabilities available to maximize energy conservation, eliminate scale, and reduce corrosion to acceptable levels. Control of chemical levels was also inconsistent and testing ability paralleled the check analysis results mentioned earlier. These corrosion reports show that there is a wide range of expertise, capability, management emphasis, and effectiveness at base level. (10:--)

In summary, the status of boiler water treatment since publication of AFR 91-40 in 1984 can best be described as still transitioning towards the goal of an effective in-house program using generic chemicals. Formal technology transfer for engineers and technicians is slowly meeting each base's requirements. Use of the central laboratory supply is providing the standardization needed by technicians as they transfer between bases. The check analysis program indicates that bases require more management emphasis in testing accuracy. Finally, base-level personnel still use expensive proprietary chemicals and the services of commercial water treatment companies in their day-to-day boiler water treatment program. This last item has strong correlation to the level of technology transfer and expertise available at the installation.

THE PROBLEM

As explained above, base-level expertise in IWT and technology transfer directly affect a base's boiler water treatment program. In September 1987, HQ AFESC/RDC submitted a research topic to Air Command and Staff College requesting improved techniques for technology transfer. This further emphasizes the need for a vehicle other than formal schools to get technology to the working level, which includes the managers

overseeing the boiler water treatment program.

In the author's view, base-level management emphasis depends on three items. First, engineering and operational personnel need a mutually supporting level of expertise. Second, managers need quantitative information suitable to support economic analysis and produce a strong argument to commit funds. Third, the base needs an advocate to push the program. Note the common thread of expertise that interconnects these points. Technology transfer is, therefore, a key to management emphasis.

There are many factors observed by the author in addition to those already mentioned that contribute to a lack of boiler water treatment technology transfer.

1. The variation in water quality makes it difficult to simplify water treatment down to a few rules of thumb.

2. Water treatment is an operations function, with engineers usually getting involved only during construction projects or energy studies.

3. Managers view water treatment as either simple or complex and tend to expect the operational personnel to be fully knowledgeable.

4. Historical quantitative data dealing with treatment and steam systems is practically nonexistent. Current data tied to predictive calculations depends on the level of engineering expertise available to answer the "what if" question.

5. Many personnel, such as boiler operators, mechanics, steamfitters, and plumbers, influence boiler water treatment without fully understanding the effect of their actions.

6. Engineering and operational personnel have limited time to extensively study the subject or experiment with treatment. Anything that requires little time stands a greater chance for implementation or use.

The bottom line is economics. Increasing in-house expertise and developing a system-wide appreciation for the benefits of water treatment will only produce positive results. Following the Air Force guidance in boiler water treatment provides safe, efficient operation on the water side of our boilers at the lowest life cycle cost. The culmination of boiler water treatment expertise is accurate testing and interpretation of test results which detects problems and allows corrections to the steam systems before the base populace even notices.

To bridge this knowledge and experience gap, this staff analysis proposes an "expert" computer program to aid base-level technicians, engineers, and managers in their implementation and maintenance of a sound boiler water treatment program. The computer program will act as an "expert" system by performing tedious calculations and evaluating calculated results against actual data. The goal is to aid technology transfer and provide a useful tool for base personnel to evaluate options and performance. The initial quantitative data provided can form a basis for economic analysis, and the qualitative output can initiate management emphasis. Hopefully, it will also spur advocacy of boiler water treatment as the recognition of a problem and its significance are major milestones towards problem solution.

RESEARCH GOALS

The publication of an updated AFR 91-40 occurred on 18 September 1987. The update was in two parts. A revised regulation by the same title and number contains the basic management requirements. The technical guidelines for implementation were split out into AFP 91-41, Industrial Water Treatment Procedures. The following tasks are set out for the "expert" computer program based upon the current publications:

1. Consolidate 23 pages of procedures found in AFP 91-41 for calculating boiler water treatment.

2. Determine the chemical treatment daily dosages beyond that provided by the initial dosage concept of the AFP 91-41 procedures.

3. Provide warnings whenever system test results indicate a problem in the operation of any mechanical component.

4. Compare actual daily chemical dosages for a given system operating condition to calculated dosages and interpret them to provide direction and management emphasis.

5. Provide a means for predictive analysis to gather data on the effects of system or chemical treatment changes. This data then becomes the basis for economic analysis to make comparative cost decisions.

Prior to delving into the computer program developed in this research effort, the next chapter attempts to reveal the basic concepts of the involved topics--"expert" computer systems and boiler water treatment.

Chapter Two

BACKGROUND

Certain concepts presented in this study may be new to the reader. This chapter seeks to provide sufficient clarification to meet the needs of those so interested.

"EXPERT" COMPUTER PROGRAMS

An intelligent computer program becomes an expert system when it "is capable of carrying out a task generally regarded as being difficult and requiring some degree of human expertise." (4:436) Knowledge is the key to the program, and it takes two forms: "common facts consisting of widely shared knowledge that is accepted by the professional and other accepted sources of data" and "heuristic...knowledge of good judgement and common good practice or 'rules of thumb' in a field." (5:26)

The intent of the proposed computer program is to bridge the gap between the contents of the current publications (14:--; 15:Ch1,Ch2,Ch4) and the daily operational problems that can affect a boiler and its associated systems. The "expert" computer program in the context of this project can best be described as rudimentary as it performs the calculations and analyzes for common problems, but it does not enter the realm of artificial intelligence where the program learns the state of knowledge/expertise of the engineer/technician and adjusts its presentation accordingly.

The contents of this computer program are based first upon the procedures set forth in AFP 91-41. (15:Ch2,Ch4,Ch6) Secondly, it uses "rules of thumb" gleaned from the author's research during course development for ENG 595, Industrial Water Treatment, at the AFIT School of Civil Engineering and Services. (2:--; 3:--; 7:--; 8:--) Discussions with water treatment experts in understanding the reasoning behind the current approach formed additional input. (22:--; 23:--; 24:--) Finally, sound system operation principles described in basic engineering texts complete the approach. (1:Ch1,Ch2,Ch34; 6:1-112) The most heuristic portion of the computer program consists of the estimated final system stability point--the final operating point after chemical addition which accounts for all boiler water treatment factors.

BOILER WATER TREATMENT FACTORS

Simply put, boiler water treatment compensates for the detrimental effects that various water constituents have upon the operation and life expectancy of a steam system. The system can best be understood through the steam cycle. The cycle begins with the makeup water, usually provided from the potable water distribution system. The makeup receives pretreatment to convert it to a quality more suitable to the steam cycle. Pretreatment is an economic decision and consists mainly of some form of softening to remove hardness for scale control and alkalinity adjustment to control corrosion. The makeup enters a deaerating heater to preheat the water before it enters the boiler. The heater also boils the water to drive off oxygen and carbon dioxide which cause corrosion. The effluent of the deaerating heater is called feedwater as it feeds the boiler. The boiler produces steam which the steam distribution system distributes to the heat and energy transfer equipment. As the boiler produces pure steam, the water constituents from the makeup are left behind to concentrate in the boiler water. Controlled draining of the boiler, called blowdown, keeps the concentration of the boiler water within operational limits. As the steam traverses the distribution system and gives up energy in the utilization equipment it condenses back to the liquid phase. This condensate makes excellent boiler water as it has no pretreatment requirements. The condensate return system brings this water back to the deaerating heater where it mixes with the makeup to produce feedwater. The water has come full cycle, but the systems are not absolutely tight. Leakage occurs and increased makeup is the result.

Controlling leakage in the steam distribution and condensate return systems is very important. Loss of steam and condensate, termed outleakage, wastes energy and deprives the boiler of processed, good quality feedwater. Condensate is always preferred over makeup due to its quality, except when inleakage occurs. Due to pressure restrictions in utilization equipment, a leak in a steam coil may allow untreated potable water into the condensate return system. This inleakage is even more detrimental to system operation and efficiency than outleakage. The goal is to produce pure steam and return pure condensate back to the boiler so that makeup is kept to a minimum. Minimum makeup reduces pretreatment and blowdown. Under these conditions, the chemical dosages needed to counteract scale and corrosion in the boiler water are also kept to a minimum. While proper operation of the steam cycle is the main defense against scale and corrosion, chemical treatment and testing provide the second echelon of defense. Chemical testing monitors the treatment, as well as the system performance.

Each chemical added to a boiler has a specific purpose and a number of auxiliary effects, some positive and some negative.

Any treatment must be selected to provide a good engineering balance between effectiveness, ease of use, ease of testing, and cost. AFP 91-41 outlines a program which accomplishes this using treatments that have been proven over the past 15 to 20 years. In addition, the treatments include proper consideration for the means of water quality adjustment already mentioned and not just direct chemical addition to the boiler. The following discussion will look at the most prominent aspects of boiler water treatment beginning with controlling the detrimental effects of hardness salts.

Softening of the boiler makeup water using ion exchange resins is the principal means to control hardness salts of calcium and magnesium. These salts form heat insulating scale which destroys boiler tubes and robs system efficiency. Ion exchange softening is the primary pretreatment technique and the most economical way to remove hardness before it ever enters the boiler. Only chemicals can combat hardness once it gets into the boiler.

Phosphate-based chemicals are added to combine with the calcium hardness that enters the boiler. Calcium phosphate in the form of calcium hydroxyapatite is much easier to control than calcium sulfate or calcium carbonate. Magnesium phosphate is not one of the compounds desired, however, as it is difficult to control. With sufficient hydroxyl alkalinity in the boiler, the magnesium forms brucite (magnesium hydroxide) which then further combines with silica present to form serpentine. Calcium hydroxyapatite, serpentine, and brucite are the desirable precipitants. They have very low solubilities and form most of the total suspended solids found in a boiler.

The suspended solids make up the sludge in the boiler bottom. In heavy quantities, they settle out of the boiler water and bake onto the boiler tubes. This baked-on sludge is also very heat insulating. A sludge conditioner (sodium lignosulfonate) keeps these compounds in a fluid suspension. The fluidized sludge is then readily removed from the boiler during normal boiler blowdown. Blowdown not only controls the sludge produced in the boiler, but also controls the dissolved solids. As a bare minimum, a boiler must operate with sufficient blowdown to prevent scale formation and baked-on sludge. Blowdown alone can control scale and sludge, albeit very inefficiently. However, blowdown has limited capability in controlling corrosion.

Corrosion results first and foremost from the presence of oxygen. It causes extremely detrimental pitting of the boiler metal. Mechanical removal of oxygen by boiling the water in a deaerating heater is the most efficient method. The chemical addition of sulfite completes the removal process after the deaerator. Deaerating heaters usually are not found on small

boilers, which rely on sulfite alone for oxygen scavenging. Another form of corrosion results from the breakdown of alkalinity in the boiler.

Alkalinity comes in three forms: bicarbonate (HCO_3^- ion), carbonate ($CO_3^{=}$ ion), and hydroxyl (OH^- ion). The relationship between these alkalinity forms controls the water pH in the steam system. Bicarbonate and carbonate alkalinity contribute to scale and sludge, but also chemically break down in the boiler to form carbon dioxide. The carbon dioxide then forms carbonic acid in the condensate return system. However, sufficient alkalinity of the proper form (hydroxyl) maintains the boiler at the least corrosive pH for steel. Caustic soda is added to a boiler to provide the proper range of hydroxyl alkalinity. Thus, alkalinity must be adjusted to achieve the desired results. Excessive blowdown is one means to inefficiently control the negative alkalinity forms. Control by the pretreatment system is usually the most economical. Iron in the condensate indicates corrosion is occurring. An ammonia-like chemical, called an amine, will then be needed to prevent early failure of the condensate system. Alkalinity is but one of the forms of dissolved solids present in a boiler.

The water constituents dissolved in the boiler water concentrate as a boiler generates steam. The phrase "total dissolved solids" or TDS describes the level of this concentration. To keep the steam produced pure and further hinder scale formation, boilers are blown down to limit the TDS level or any other water constituent that imposes an operational limit. Operating a boiler within 10 percent of its TDS limit optimizes water usage and energy loss in the blowdown water. Since the test to accurately measure TDS takes one to two days to perform, the boiler water's conductivity (the ability to carry an electric current) is measured instead. As conductivity is the result of dissolved solids in the water, there is a measurable relationship between the conductivity and TDS. The conductivity test takes only a few minutes.

The testing associated with water treatment not only keeps the chemical additions on track, but also monitors the well being of the mechanical components. A malfunctioning softener manifests itself by hardness in its effluent. Detection of poor quality condensate allows identification of a leaking heat exchanger. Early detection of equipment problems is a beneficial by-product of boiler water treatment. In fact, proper system operation is 90 percent of corrosion and scale control. Chemicals handle the last 10 percent.

The above background into the chemical interactions of boiler water and the purpose of "expert" systems provides a foundation to comprehend the workings of the computer program presented in the next chapter.

Chapter Three

THE COMPUTER PROGRAM

The computer program, written in WANG BASIC, consists of four parts. The main program generates a data file and performs all file maintenance functions. It also assists the user in selecting all input data for each file record. The basic subroutine performs calculations per AFP 91-41 with a few variations to allow substitution of available data versus data specifically required by the pamphlet. It also analyzes system operation and informs the user of potential problems. The advanced subroutine goes beyond the AFP 91-41 calculations and attempts to predict the final operating point of the boiler, where chemicals dosed and water flows are in balance. This system model then allows further interpretation of actual test results versus those predicted, including the comparison of calculated and actual chemical dosages. The advanced subroutine also provides a rapid method to evaluate the effects of system changes. The data generated is sufficient to develop an economic analysis of the alternatives. Finally, the enthalpy subroutine selects the enthalpy value to calculate the maximum steam production possible for the boiler's operating pressure and altitude above mean sea level. Both the basic and advanced subroutines access the enthalpy subroutine in a manner having no user interaction. The enthalpy subroutine will not be discussed further in this staff analysis.

DATA AND PROGRAM PHILOSOPHY

The program file names are "ESTMMAIN" for the main program, "ESTMAFP" for the basic AFP 91-41 calculations and system analysis, "ESTMSTST" for the advanced steady state calculations and treatment analysis, and "ESTMHG" for the enthalpy subroutine. The compiled programs use library "EIXXSRC," a standardized convention for engineering branch source code on the Civil Engineering Work Information Management System (WIMS). The object code for the main program resides in library "EIXXOBJ." The object code for the subroutines resides in library "EIXXSUBS." These are also WIMS standard conventions. These source and object codes reside in volume "PGM001." The data file "ESTM" resides in library "EIXXDATA" on volume "DAT001." The program uses IVAR data on the system to extract the user's computer ID (identification) and the volume where engineering

data resides, which is "DAT001" at Maxwell AFB. Proper storage by file, library, and volume is necessary to ensure proper linking of the main program with the subroutines. The author used called subroutines rather than one large program due to limitations in the compilier for the WANG BASIC computer language. It had difficulty compiling programs over about 2400 lines in length.

Data Records

The main program does a one-time creation of the data file and then performs all file maintenance. The records on the data file are uniquely described by a keyfield consisting of the user's computer ID, the date of record creation, a three character base ID abbreviation, a seven character building number for the boiler's location, a two character boiler designator, and a two character run indicator to describe the data in the record. A 45 character comment line allows expanded explanation of the data record's purpose, but it is not part of the keyfield. Also, at the start of the main program source code is a listing of all variables used throughout the four parts.

Data Input

The main program uses an asterisk in front of a test input to designate it as a test recommended by the pamphlet. The program also indicates the units of each input. Test inputs used in the calculations include steam quality in addition to makeup and condensate return quality. Boiler quality is used for comparison purposes only, as is the feedwater quality.

An added feature to increase comparison accuracy of the daily chemical dosage calculations to the actual dosages is the inclusion of a chemical purity input for each chemical used. While reagent grade chemicals used in chemical testing are nearly 100 percent pure, bulk water treatment chemicals are technical grade for economy and have purities ranging from 40 to 100 percent.

Tables in the main program allow selection of desired operational limits for total dissolved solids, phosphate, hydroxyl alkalinity, lignosulfonate, and sulfite levels. Suggested targets are also given with rationale. For ease of use, selecting any standard phosphate-based chemical is done simply by typing its associated number from a table. Neutralizing amine levels and dosages are not selected, but are automatically calculated to provide a 50/50 mixture of cyclohexylamine and morpholine. Other tables provided include percent of carbonate alkalinity breakdown in the boiler and the distribution ratio of the neutralizing amines. These tables attempt to improve understanding and increase accuracy of the advanced calculations.

Finally, the last function during the creation of the file record is the input of the chemical dosages on a pound per day basis. If the base uses nonstandard chemicals (chemicals not found in AFP 91-41), this section allows the inclusion of their alternate product names. Appendix 5 contains the sequence of screens presented to the user to provide the data described above to create a file record.

Record Editing

The edit sequence for a file record can be followed in Appendix 6 and allows the user to review just the data in the record by selecting action number 1 in the screen shown at the bottom of page A6-3. In addition to this ability to review the record data, the user can review the selection criteria using the action numbers shown. Selection criteria action numbers directly access the associated specific subsections of the file record create sequence as described in Appendix 5.

The edit sequence has a unique feature in the multiple use of the screen shown at the top of pages A6-3 and page A6-9. Upon first appearance of this screen, the user can thumb through the data base by going to the next record, display the keyfield and comment line, select the file record for review and edit, or exit from the screen without taking any action. If the user enters a record for review or edit, upon the second appearance of this screen, the user must determine the handling of the record. Three options are available. First, by selecting action (R), the user can retain the existing record name (keyfield) with any changes that may have been made. Second, the edited record may be renamed by selecting action (C) and altering the keyfield displayed. This creates a new record, but also retains the old record with its unedited data and old name. Finally, by selecting action (E) the user exits from the screen without making changes to record data or keyfields. The remaining main program functions are one-time creation of the data file upon the first use of this program, the deletion of records following the instruction logic already provided, and the access of the call subroutines for calculations.

Execution

As the user creates a data record, the program displays basic decision criteria and suggests inputs. It provides warnings about assumptions made to simplify AFP 91-41 and highlights or clarifies proper treatment philosophy. It also indicates where data can be found for program input. The requested input goes far beyond that needed to perform AFP 91-41 calculations, but the data should nevertheless be available on any major installation. Smaller installations may have to request limited support from the nearest main base or their supporting engineering function. The call subroutines allow selection of a data record and then

perform their calculations and analysis based on the data in that record. A decision for a hardcopy printout of the results is available at the end of the calculations. Both subroutines use the screen to scroll through the results prior to the printout decision. Once the calculations start, however, the user has no capability to stop the program, unless he has been given the "help" key by the computer system administrator.

A feature of this program not contained in AFP 91-41 is massflow analysis. A water constituent in a water flow should maintain its mass throughout the system, unless a specific treatment alters it or an undesirable condition is present. For example, the following calculations track calcium hardness through the steam cycle.

$$Xmu*Qmu + Xcr*Qcr = Xf*Qf$$
$$Xf*Qf = Xbd*Qbd + Xs*Qs$$
$$Xs*Qs = Xl*Ql + Xcr*Qcr$$

Where, X = calcium hardness in ppm as CaCO3
Q = pounds of water per hour
mu = make up water after any pretreatment
cr = condensate returned to the boiler
f = feedwater
bd = blowdown
s = steam
l = losses, steam and condensate

A specific need for massflow analysis is the calculation of feedwater quantities. The author found that most boilers had some way of getting a makeup and a condensate return sample. Sampling feedwater, however, was difficult if not impossible. Thus, the feedwater inputs to the program are used for comparison only and do not participate in any further calculations. Note that AFP 91-41 bases all calculations on feedwater tests. The P alkalinity test is the only feedwater test used by the program, as P alkalinity does not follow massflow analysis through the deaerating heater.

Another feature not emphasized in AFP 91-41 is the variation of the quantity called "gallons" throughout the steam cycle. A gallon is a volume measurement that does not take into account the effects of pressure and temperature. AFP 91-41 assumes all feedwater weighs 8.33 pounds per gallon and uses this information to calculate the phosphate dosage. At normal potable water distribution conditions, a gallon of water weighs about 8.33 pounds. But, a gallon of water boiling at 150 pounds per square inch gauge weighs 7.353 pounds. A steam table can provide the specific volume (cubic feet per pound) of water under many conditions. (6:1-112) The user may select a more accurate pounds-per-gallon figure from the screen shown on page A5-13 or use the following equation.

Pounds/gallon = 0.1337 / specific volume

A clarification of other program aspects that expand upon AFP 91-41 is now in order.

The user indicates the processes available in the pretreatment system. However, due to the multitude of potential effects, it is left to the user to adjust the water qualities accordingly. This is not a problem if testing the effluent of the pretreatment system is possible. A problem arises when the intent is to predict the effect of system changes. The user should adjust makeup quality as a minimum; condensate quality may also need changing. Other predictive changes may require other adjustments.

From an operational standpoint, both calculation call subroutines take the rated steam capacity and, using altitude above mean sea level and feedwater temperature, calculate the maximum steam capacity possible for the boiler. The subroutines compare this result to the steam capacity being analyzed to ensure detrimental oversteaming is not occurring.

BASIC CALCULATIONS

The screens to access the basic calculations are the most straightforward. As mentioned previously, the calculation programs use the data from the selected record, provide an output on the screen for review, and provide a hardcopy of the results upon request. There are two ways to structure the data in a record for input to the basic calculations, one to optimize for AFP 91-41 calculations and one to optimize for analysis of system operation. The differences are striking.

To optimize the AFP 91-41 calculations, the user should start by locking a tested feedwater quality into the calculations. Only an operating system can provide this information. As the program is based upon the massflow calculations described earlier, making the makeup and condensate return quality values equal to the tested feedwater quality will fix the values of the feedwater quality in the calculations. Also, this will cause the program to warn of poor quality condensate and, possibly, of pretreatment problems. This is somewhat unrealistic because the feedwater quality will probably change for the operating conditions calculated by the program. Next, the user should set the steam and condensate losses to zero and make the steam quality pure, since AFP 91-41 assumes zero losses and pure steam. Finally, the oxygen content in the feedwater (the effluent of the deaerating heater) should be set to the minimum value of 0.007 ppm oxygen (as O_2). AFP 91-41 assumes no oxygen in the feedwater.

Quite logically, to analyze system operation the data should reflect actual system operation. Specifically, the makeup, condensate return, and steam qualities should reflect actual tests or test averages over a given period. Also, since all systems leak to some extent, estimated water loss should not be zero. The user can determine an average water loss over a month by taking the difference between the average monthly makeup and blowdown as recorded on the AF Form 1459, Water Treatment Operating Log for Steam and Hot Water Boilers, or AF Form 1464, Monthly Steam Boiler Plant Operating Log.

The final point to be made concerning the basic calculations deals with the need for caustic soda addition. The only caustic soda dosage calculated is that needed for phosphate hydrolysis. Naturally occurring alkalinity is not taken into account in its ability to meet this need. Also, AFP 91-41 does not calculate the caustic soda needed for residual hydroxyl alkalinity or any other chemical reaction. Thus, the basic calculations for caustic soda may miss the real world requirements. The advanced calculations try to overcome the limitations in the basic calculations.

ADVANCED CALCULATIONS

The advanced calculations provide a better estimate of chemical dosages and expected test results to be found in the boiler. This call subroutine can then compare predicted tests and dosages to actual values. The basic and advanced calculations use total dissolved solids and silica to predict the final operating point for the boiler. In addition, the advanced calculations provide the following for total suspended solids: a makeup limit, an estimated test value limit, the cycles of concentration design limit, and the predicted actual cycles of concentration. Other modifications to the basic calculations provide increased accuracy.

Instead of using total hardness to calculate phosphate requirements, the advanced calculations use only calcium hardness. Magnesium hardness reacts with hydroxide and silica if available in sufficient quantity. This program provides warning if this is not the case. Magnesium phosphates are not desirable in a boiler, and the advanced calculations do not predict their formation. As for oxygen, the advanced calculations include determining the sulfite required to combine with any oxygen not removed by the deaerating heater. The effective operation of the deaerating heater is one system operation analysis included in the advanced calculations. There are two qualitative determinations provided in the advanced calculations, which do not increase accuracy but increase understanding of expected system final operating conditions.

Results of the naturally occurring hydroxyl alkalinity prediction in the boiler along with the neutralizing amine dosages can only suggest qualitative analysis. These constituents undergo so many complex interactions that precise estimates cannot be given. However, they do indicate the potential for gross problems in boiler operation. The program provides appropriate warnings. The accuracy of the predicted final operating point of a boiler rests with the iterative nature of the advanced calculations and the final interpretation of all information.

The main difference between the basic and advanced approaches is the multiple recalculation (iteration) of the chemical dosages and associated effects by the advanced program. The advanced program determines the resultant effects of the chemicals dosed and reaccomplishes the calculations after altering the makeup water quality accordingly. Thus, the quality of the makeup includes the effects of chemical treatment and becomes the principal variable in calculating makeup flow during each iteration. The program then chooses the largest makeup required between that needed for total dissolved solids or that needed for silica. Makeup, steam, and loss flows then calculate condensate return, feedwater, and blowdown. The cycles of concentration used for further calculations are equal to the feedwater flow divided by the blowdown flow. The program continues to perform iterations until the difference in the cycles of concentration between successive runs is within 0.0000001 cycle.

ANALYSIS AND INTERPRETATION

One convenience provided in the advanced calculations is the ability to constrain makeup flow to a given value. This greatly eases the comparison of predicted results with actual operation. Page A9-3 shows the sample screen, and Appendix 12 contains a sample hardcopy output. The main benefit from constraining the makeup is to fix the residual values of the chemicals dosed. Thus, any variation between predicted and actual dosages then stems from testing accuracy, which varies from correct values by over 30 percent about 50 percent of the time, inaccurate sampling techniques, defective system operation, or improper chemical feeding. Another point to remember is the overall nature of a steam system. Every flow is not consistent with every other flow at every moment. This means that averaging input values to this computer program over a month's time will be much more representative of overall system operation than using tests taken on one or two days.

Due to the many variables involved, including those not considered in this program, it is unwise to base a decision on a single calculation result. It is best to view the results as a composite whole that must interrelate. For example, the user

should compare the pressure and temperature on a deaerating heater, the design oxygen effluent of the heater, the daily sulfite dosage, the feeding method of the sulfite chemical, the chemical test procedures for sulfite, and any test procedures for measuring oxygen in the feedwater to determine if the sulfite dosage is in line and if the deaerating heater is operating properly. If the program prints out a warning, further investigation is necessary.

Thus, the first step recommended by the author to analyze an existing system is to use the basic calculations on actual system data, data not configured for the AFP 91-41 approach, to obtain an evaluation of the system operation. The next step is the use of constrained makeup in the advanced calculations to further understand the treatment and how the treatment interacts with the system operation. For example, adjusting the oxygen in the feedwater until the calculated sulfite dosage equals the actual dosage will provide a feedwater oxygen value that can be compared to an actual oxygen test. If predicted and actual oxygen values do not match, the user should look for reasons other than deaerator operation for the difference. Finally, results from using unconstrained makeup in the advanced calculations will indicate boiler operation under an AFP 91-41 treatment program. One caution--the makeup requirements, cycles of concentration, and design/actual operating levels for total dissolved solids, silica, and total suspended solids must always receive a review. If silica is the limit, then silica testing in the boiler water should begin. If the total suspended solids require the highest makeup or the lowest cycles of concentration, sludge may become a problem. In any case, the goal is energy conservation, efficient operation, and a clean bill of health during the annual boiler inspection.

One benefit of this program at every installation is the comparison of proprietary chemical treatments to AFP 91-41 treatment. As a minimum, this comparison of energy lost in blowdown, water use, and daily chemical dosages will provide the data needed in an economic evaluation.

A potential benefit is the base-level involvement of major command, AFIT, and AFESC industrial water treatment engineers through the use of this computer program. An installation having a problem with their treatment can provide the data requested in this computer program to form the basis of discussion with other experts. Most water treatment problems, in the author's experience, require broad data gathering to focus on the key elements and develop a solution.

A review of the hardcopy appendices and the next chapter will illustrate the analysis used by the author in the investigation of boiler number four at Maxwell AFB's Central Energy Plant.

Chapter Four

VALIDATION

Validation of any computer program ensures it works under all conditions and situations. However, the level of effort to validate this project can conservatively be estimated to exceed the time expended to develop and report on it. The following explains the strengths and weaknesses of this computer program during its application using Maxwell AFB plant data. The next chapter further clarifies these points in view of the research goals of this project. A plus for the output of this program is the implementation of the recommended changes in treatment. In this case, Maxwell AFB's civil engineering management is improving the pretreatment system and converting to AFP 91-41 based treatment.

MAXWELL AFB CENTRAL ENERGY PLANT DATA

Upon the advice of central plant personnel, the author selected boiler number four for analysis. This boiler, like the other four boilers in the same plant, operates at a pressure of 150 pounds per square inch gauge and has a rated capacity of 22,000 pounds of steam per hour. The author selected December 1987 for analysis due to winter operation and the ability to run additional tests for data not normally available. Current treatment consists of sodium sulfite fed to the deaerating heater, sodium hexametaphosphate and a proprietary sludge conditioner fed to the boiler, and a neutralizing amine (cyclohexylamine) fed to the steam header. Blowdown is continuous off the steam-water interface, and the bottom receives a blowdown two to three times a week. The boiler has a combustion efficiency of 76.2 percent and produced 45.7 percent of the total steam that month.

Results using actual system data in the basic calculations subroutine indicated excessive losses during the analysis month. A nonindustrial installation like Maxwell AFB should have losses between 1 and 5 percent of steam produced, whereas 15.67 percent loss occurred. The deaerating heater is not working properly and cannot achieve the design level of 0.04 ppm oxygen (as O_2) in its effluent. Finally, plant personnel explained that due to direct contact steam cooking, morpholine could not be used. It has

been Air Force policy since the early 1970's to replace all direct contact steam cooking equipment with jacketed equipment. While the former equipment is cheaper, its purchase sentences the condensate return system to excessive corrosion because neutralizing amines cannot be used. Economics dictate replacing the steam equipment, rather than the condensate system.

Advanced calculations, with or without constrained makeup, repeatedly indicated a total suspended solids problem with the boiler. This is consistent with information from the last boiler inspection. The plant manager was investigating the use of increased blowdown, which would reduce this problem while further increasing the energy loss, water use, and chemical consumption.

These advanced calculations demonstrated no need to feed caustic soda to the boiler for hydroxyl alkalinity, although the basic calculations called for a daily dosage. Unfortunately, predicted levels of hydroxyl alkalinity were much too high compared to actual levels measured. Thus, further validation is necessary in this area with other water qualities. The proprietary sludge conditioner may have had an effect on the boiler pH and this prediction.

Constrained makeup calculations indicated about 0.485 ppm oxygen (as O_2) in the feedwater, a tenfold increase over expected. As for other chemical levels, the dosages predicted rarely came within ten percent of the actual values. This can indicate testing accuracy problems or that the one time tests performed to get certain input values for the computer program diverged significantly from the average. Other possibilities include incorrect modeling of the primary chemical reactions expected in the boiler or unexpected reactions actually occurring. To evaluate these requires more analysis under varied conditions.

The predictive calculations indicated that reducing the steam and condensate losses would give the greatest improvement. This is as expected. These calculations also predicted the same problems of high total suspended solids and high hydroxyl alkalinity in the boiler. The former is due to using phosphate on unsoftened makeup water with a significant makeup water demand. The latter is due to the high levels of naturally occurring alkalinity in the makeup water. Split-stream softening of the central plant's makeup water eliminates these conditions.

The results of the computer-based analysis coupled with the author's experience provided the recommended treatment changes. However, while the program flagged the need and suggested solutions to investigate, the author's expertise selected the final approach. The recommended treatment changes below are <u>not</u> the output of the "expert" system, but do use the results of the program as input for the operation and economic analysis.

RECOMMENDED TREATMENT CHANGES

Based on initial calculations, split-stream softening in the proportion of 71 percent of the flow through a hydrogen zeolite softener and 29 percent through a sodium zeolite softener will eliminate the total suspended solids and hydroxyl alkalinity problems in the boiler. Softening removes calcium and magnesium in the makeup, eliminating the high production of the large calcium hydroxyapatite molecule which is the main contributor to suspended solids. The hydrogen from the hydrogen zeolite converts alkalinity into carbon dioxide for removal in a degasifier column. The blended output of the two streams can produce a regulated amount of hydroxyl alkalinity in the boiler. This blending also eliminates the need for any caustic soda addition to the boiler. Nevertheless, this recommendation should conclude with an economic analysis to illustrate any benefits.

Four softeners, two each of each type to provide immediate backup and never allow hard water into the boilers, will cost approximately $10,000 complete. They will handle the flow rates and softening capacity for the whole central energy plant, not just boiler number four. The softeners should have a life expectancy of 15 years. Replacement of the resins at the eight year point will cost another $5,000. Regeneration chemicals to replenish the resins will add a yearly charge of $155 for salt and $3,215 for sulfuric acid. The effective annual cost of this additional effort is $4,995 over the 15 years at a 10 percent interest rate. The basis for these figures is a total plant annual makeup requirement of 7 million gallons containing 40 ppm calcium hardness, 4 ppm magnesium hardness, and 200 ppm M alkalinity (all units as $CaCO_3$).

The energy savings for the reduction in blowdown due to the new softeners and repair of the deaerating heater comes to about $5,095 per year. Water savings add another $400 per year. Chemical savings per year due to the recommended pretreatment and reduced blowdown come to $1,725 for phosphate, $400 for sulfite, $1,015 for neutralizing amine, and $7,865 for sludge conditioner. The sludge conditioner savings stem mainly from conversion from the proprietary chemical now being used to the sodium lignosulfonate listed in AFP 91-41. To compensate for the addition of morpholine to the cyclohexylamine already used, the neutralizing amine savings listed is half that estimated. Morpholine use is contingent upon elimination of direct contact steam cooking. These annual savings come to $16,500. Thus, the effective annual savings of the new pretreatment is $11,505. The payback of ten months on first year investment is an attractive return. Reducing steam and condensate losses below five percent will more than triple these savings. The above figures are conservative and illustrate typical improvement for medium-sized central plants, especially when converting from proprietary chemicals to AFP 91-41 generic chemicals.

Chapter Five

FINDINGS

The "expert" computer program can improve the technology transfer of boiler water treatment by aiding the analysis and interpretation of treatment alternatives. However, to get to the point where it rivals formal schools will require many more lines of computer code than currently written. The problem rests with the many variations in possible chemical and system interactions, resulting in large decision trees to select a response to a single parameter. Therefore, at this time, the computer program is more applicable for use by formal school graduates than for general use by base personnel.

One area demonstrated during the development of this program to require some expertise is the adjustment of record data to model alternate courses of action. This requires an experience level far above that which can be programmed into the "expert" system at this time. In particular, the user needs a grasp of the capabilities and output quality of pretreatment systems and their overall effect upon the system using the makeup water quality in question.

The continued validation of this computer program should center on the advanced calculations and their determination of chemical dosages, interpretation of these against actual dosages, and the resulting benefit of predictive analysis. There was excessive difference between calculated and actual dosages for each chemical used at Maxwell AFB under the constrained makeup advanced calculation mode. These differences can be due to problems in sampling, testing, chemical feeding, or the basic assumptions behind the calculations themselves. The author primarily suspects the testing and assumptions. Testing accuracy is one possibility, but a more likely one is the use of single test results in the data record for some inputs while others were monthly averages. The single test may have been taken at a moment when the values tested were not representative of the average situation throughout the month. As for the assumptions in the calculations, one water quality and one boiler are insufficient to declare success or failure. The calculations must be run against other systems at other locations to clarify their deficiencies and validate their accuracy.

CONCLUSIONS

The consolidation of AFP 91-41 procedures in the computer program and the step-by-step process to create a data record does improve understanding and saves many hours of computation by hand calculator. One interesting response from the Maxwell AFB plant personnel occurred when they learned that the boiler's altitude above mean sea level affects its maximum steam production. Being ex-Navy shipboard boilermen like many other Air Force civilian plant personnel, they never had to consider altitude. This one point of technology transfer should increase the awareness of the potential to oversteam and damage a boiler.

Another positive action during program development was the interaction between plant, engineering, and management personnel. The data collection required promotes this interaction as does the interpretation of warnings identified by the calculation subroutines. This initial dialogue can become the basis for consistent management review and emphasis.

Computer warnings concerning mechanical system operation were effective in identifying problems at the Maxwell AFB central energy plant. However, to limit the variables involved, the decision trees concentrated upon hardness, total suspended solids, and alkalinity leakage from the more common pretreatment systems; the pressure and temperature of deaerating equipment; the quality of returned condensate; and the amount of steam and condensate losses. As warnings get more specific, the decision trees must test the interrelationship between and among more variables. Even then there is probably more than one reason for the warning to occur. Thus, rather than identify every possible situation, the warnings were made general enough to flag a problem and provide areas for further investigation.

RECOMMENDATIONS

Distribution of the computer program should be limited initially to major command industrial water treatment engineers and graduates of the AFIT course, ENG 595, Industrial Water Treatment. A one year application test with feedback to AFESC/DEMM and AFIT/DEE will expand the validation data base. This is particularly necessary to ensure that instructions and warnings in the program cover the full range of water quality. It will also identify the prediction accuracy of the basic chemical reactions coded into the program. After the year long test, AFESC can decide to distribute this report and associated computer program on floppy disk to each installation or to limit it to graduates of formal industrial water treatment courses.

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APPENDICES

Main Program for Data Record Management and Input Selection..... A1-1
Call Subroutine for Basic Calculations per AFP 91-41 and System Operation Analysis..... A2-1
Call Subroutine for Advanced Calculations and Treatment Analysis..... A3-1
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Hardcopy Output of Advanced Calculations and Treatment Analysis..... A11-1
Hardcopy Output of Advanced Calculations and Treatment Analysis with Constrained Makeup and Adjusted Feedwater Oxygen..... A12-1

Appendix One

MAIN PROGRAM FOR DATA RECORD MANAGEMENT
AND INPUT SELECTION

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000010 * THIS PROGRAM CALCULATES THE MASS FLOW QUANTITIES AND CHEMICAL
000012 *   DOSAGES FOR STEAM BOILER WATER TREATMENT USING RATED BOILER
000014 *   QUANTITIES ADJUSTED FOR ACTUAL OPERATING CONDITIONS, QUALITY
000016 *   OF AVAILABLE MAKEUP, AND QUALITY OF CONDENSATE RETURNED
000018 *   ACCORDING TO AFP 91-41, INDUSTRIAL WATER TREATMENT PROCEDURES,
000020 *   (18 SEPTEMBER 1987) AND BEYOND.
000022 *
000024 * THE MAIN PROGRAM CREATES AND MAINTAINS DATA RECORDS ON THE FILE.
000026 *   THE CALCP SUBROUTINE ANALYZES SYSTEM OPERATION AND CALCULATES
000028 *     CHEMICAL DOSAGES ACCORDING TO AFP 91-41.
000030 *   THE CALCS SUBROUTINE CALCULATES CHEMICAL DOSAGES AT THE
000032 *     ESTIMATED FINAL SYSTEM OPERATING POINT, TAKING INTO ACCOUNT
000034 *     THE MAJOR CHEMICAL REACTIONS AND THEIR EFFECTS, AND ANALYZES
000036 *     THE TREATMENT ACTUALLY BEING PROVIDED TO THE BOILER.
000038 *
000040 *****     DESCRIPTION OF VARIABLES
000042 *
000044 *    VARIABLE      DESCRIPTION
000046 *
000048 *      XXXX(N)     AN ITERATED VARIABLE USED IN ADVANCED
000050 *                    CALCULATION SUBROUTINE
000052 *                    XXXXX DENOTES ANY CHARACTER STRING
000054 *      AMSL        ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL
000056 *      BASE$       INSTALLATION WHERE BOILER IS LOCATED
000058 *      BASEID$     BASE ID 3 LETTER ABBREVIATION
000060 *      BICARBF     BICARBONATE ALKALINITY IN FEEDWATER
000062 *      BLDG$       BUILDING NUMBER WHERE BOILER IS LOCATED
000064 *      BLRSI       OPERATING LEVEL OF SILICA IN BOILER
000066 *      BLRTDS      OPERATING LEVEL OF TDS IN BOILER
000068 *      BLRTSS      OPERATING LEVEL OF SUSPENDED SOLIDS IN BOILER
000070 *      BLR$        BOILER DESIGNATION (NUMBER, LETTER, BOTH, OR ?)
000072 *      CACR        CALCIUM HARDNESS IN CONDENSATE RETURN
000074 *      CAF         CALCIUM HARDNESS IN FEEDWATER BY CALCULATION
000076 *      CAFT        CALCIUM HARDNESS IN FEEDWATER BY TEST
000078 *      CAMU        CALCIUM HARDNESS IN MAKEUP
000080 *      CARBF       CARBONATE ALKALINITY IN FEEDWATER
000082 *      CARBPC      % CARBONATE ALKALINITY BREAKDOWN IN BOILER
000084 *      CDOF        CARBON DIOXIDE IN FEEDWATER
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000086 *       CHADR         DISTRIBUTION RATIO FOR CYCLOHEXYLAMINE
000088 *       CHAF          CYCLOHEXYLAMINE PPM REQUIRED IN FEEDWATER
000090 *       CHAPC         PER CENT CYCLOHEXYLAMINE IN CHEMICAL USED
000092 *       CHAPCBD       PER CENT CYCLOHEXYLAMINE IN BLOWDOWN
000094 *       CHAW          WEIGHT OF CYCLOHEXYLAMINE DOSAGE PER DAY
000096 *       CHEMCYC(N)    CYCLES OF CONCENTRATION CONSIDERING CHEMICALS
000098 *                      DOSED TO BOILER (ITERATION)
000100 *       COMMENT$      COMMENT EXPLAINING THE NATURE OF THE DATA
000102 *                       RECORD - USE AS SEE FIT
000104 *       CUCR          COPPER IN CONDENSATE RETURN
000106 *       CYC           CYCLES OF CONCENTRATION
000108 *       CYCSIA        ACTUAL CYCLES BASED ON SILICA
000110 *       CYCSID        CYCLES BASED ON SILICA - DESIGN LIMIT
000112 *       CYCTDSA       ACTUAL CYCLES BASED ON TDS
000114 *       CYCTDSD       CYCLES BASED ON TDS - DESIGN LIMIT
000116 *       CYCTSSA       ACTUAL CYCLES BASED ON TSS
000118 *       CYCTSSD       CYCLES BASED ON TSS - DESIGN LIMIT
000120 *       DATE$         DATE (YYMMDD)
000122 *       DEEDATAVOL$   VARIABLE NAMING VOLUME WHERE ENGINEERING DATA
000124 *                       IS STORED BY WIMS CONVENTION
000126 *       DENSF         DENSITY OF FEEDWATER IN POUNDS/GALLON
000128 *       DMGF          DELTA VARIABLE FOR MAGNESIUM IN FEEDWATER TO
000130 *                       ACCOUNT FOR COMBINATION WITH SILICA
000132 *       DNAOHWR       ESTIMATED CAUSTIC SODA WEIGHT THAT CAN BE
000134 *                       REDUCED DUE TO NATURALLY OCCURRING ALKALINITY
000136 *                       IN THE FEEDWATER TO MEET DESIRED RESIDUAL
000138 *       DTDSXXX       DELTA VALUE FOR VARIABLE XXX FOR COMPUTING
000140 *                       DTDSMU(N)
000142 *       DTSSXXX       DELTA VALUE FOR VARIABLE XXX FOR COMPUTING
000144 *                       DTSSMU(N)
000146 *       DSIMU(N)      SUMMARY DELTA VALUE AFFECTING SILICA IN THE
000148 *                       MAKEUP
000150 *       DTDSMU(N)     SUMMARY DELTA VALUE AFFECTING TDS IN THE
000152 *                       MAKEUP
000154 *       DTSSMU(N)     SUMMARY DELTA VALUE AFFECTING TSS IN THE
000156 *                       MAKEUP
000158 *       DXXXX         DELTA VALUE FOR VARIABLE XXXX FOR COMPUTING
000160 *                       EFFECTS OF CHEMICALS DOSED
000162 *       EIXXDATA      ENGINEERING DATA LIBRARY IN COMPUTER
000164 *       ESTM          FILE NAME - (E)NGINEERING (ST)EA(M) FOR ALL
000166 *                       RECORDS IN COMPUTER
000168 *       FE            FACTOR OF EVAPORATION
000170 *       FECR          IRON IN CONDENSATE RETURN
000172 *       FWOH          EQUIVALENT OH IN FEEDWATER FROM ALL SOURCES
000174 *       HG            ENTHALPY OF SATURATED VAPOR
000176 *       HGH           ENTHALPY HIGH
000178 *       HGL           ENTHALPY LOW
000180 *       IPLVOL$       VARIABLE NAME FOR VOLUME WHERE DATA IS STORED
000182 *                       IN COMPUTER
000184 *       LBCHA         AVERAGE DOSAGE CYCLOHEXYLAMINE POUNDS/DAY
000186 *       LBLSN         AVERAGE DOSAGE LIGNOSULFONATE POUNDS/DAY
000188 *       LBMOR         AVERAGE DOSAGE MORPHOLINE POUNDS/DAY
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000190 *       LBOH         AVERAGE DOSAGE CAUSTIC SODA POUNDS/DAY
000192 *       LBOTHAM      AVERAGE DOSAGE OTHER AMINE USED POUNDS/DAY
000194 *       LBOTHLSN     AVERAGE DOSAGE OTHER SLUDGE CONDITIONER USED
000196 *                      POUNDS/DAY
000198 *       LBOTHOH      AVERAGE DOSAGE OTHER HYDROXYL CHEMICAL USED
000200 *                      POUNDS/DAY
000202 *       LBOTHPHS     AVERAGE DOSAGE OTHER PHOSPHATE CHEMICAL USED
000204 *                      POUNDS/DAY
000206 *       LBOTHSF      AVERAGE DOSAGE OTHER OXYGEN SCAVENGER USED
000208 *                      POUNDS/DAY
000210 *       LBPHS        AVERAGE DOSAGE PHOSPHATE CHEMICAL POUNDS/DAY
000212 *       LBSF         AVERAGE DOSAGE SULFITE POUNDS/DAY
000214 *       LSNBD        LIGNOSULFONATE RESIDUAL IN BOILER BLOWDOWN
000216 *       LSNBDT       LIGNOSULFONATE LEVEL IN BLOWDOWN BY TEST
000218 *       LSNPC        PER CENT OF TANNIC ACID IN LIGNOSULFONATE USED
000220 *       LSNW         WEIGHT OF LIGNOSULFONATE DOSED PER DAY
000222 *       LSNWR        WEIGHT OF LIGNOSULFONATE DOSED FOR RESIDUAL
000224 *       LSNWMAF      WEIGHT OF LIGNOSULFONATE DOSED FOR ALKALINITY
000226 *       M            ITERATION COUNT = N - 1
000228 *       MABD         M ALKALINITY ESTIMATED IN BLOWDOWN
000230 *       MACR         M ALKALINITY IN CONDENSATE RETURN
000232 *       MAF          M ALKALINITY IN FEEDWATER BY CALCULATION
000234 *       MAFT         M ALKALINITY IN FEEDWATER BY TEST
000236 *       MAMU         M ALKALINITY IN MAKEUP
000238 *       MGCR         MAGNESIUM HARDNESS IN CONDENSATE RETURN
000240 *       MGF          MAGNESIUM HARDNESS IN FEEDWATER BY CALCULATION
000242 *       MGMU         MAGNESIUM HARDNESS IN MAKEUP
000244 *       MORDR        DISTRIBUTION RATIO FOR MORPHOLINE
000246 *       MORF         MORPHOLINE PPM REQUIRED IN FEEDWATER
000248 *       MORPC        PER CENT OF MORPHOLINE IN CHEMICAL USED
000250 *       MORPCBD      PER CENT OF MORPHOLINE IN BLOWDOWN
000252 *       MORW         WEIGHT OF MORPHOLINE REQUIRED PER DAY
000254 *       N            ITERATION COUNT
000256 *       NAOHPC       PURITY (%) OF OH IN CHEMICAL USED
000258 *       NAOHW        WEIGHT-CAUSTIC SODA REQUIRED PER DAY
000260 *       NAOHWCAF     WEIGHT-CAUSTIC SODA FOR PO4 HYDROLYSIS-CALCIUM
000262 *       NAOHWMGF     WEIGHT-CAUSTIC SODA FOR MAGNESIUM REACTIONS
000264 *       NAOHWMGF1    WEIGHT-CAUSTIC SODA FOR MAGNESIUM HYDROXIDE
000266 *       NAOHWMGF2    WEIGHT-CAUSTIC SODA FOR MAGNESIUM (SERPENTINE)
000268 *       NAOHWPH      WEIGHT-CAUSTIC SODA FOR PO4 HYDROLYSIS-AFP91-41
000270 *       NAOHWR       WEIGHT-CAUSTIC SODA FOR RESIDUAL
000272 *       OHBD         HYDROXYL ALKALINITY RESIDUAL IN BOILER BLOWDOWN
000274 *       OHBDT        HYDROXYL ALKALINITY LEVEL IN BOILER BY TEST
000276 *       OHD          HYDROXYL ALKALINITY DEFICIENCY IN BOILER
000278 *       OHF          HYDROXYL ALKALINITY IN FEEDWATER
000280 *       OHT          TOTAL HYDROXYL ALKALINITY IN BOILER
000282 *       OPR$         INDIVIDUAL CREATING RECORD
000284 *       OTHAM$       NAME OF OTHER AMINE USED
000286 *       OTHLSN$      NAME OF OTHER SLUDGE CONDITIONER USED
000288 *       OTHOH$       NAME OF OTHER HYDROXYL CHEMICAL USED
000290 *       OTHPHS$      NAME OF OTHER PHOSPHATE CHEMICAL USED
000292 *       OTHSF$       NAME OF OTHER OXYGEN SCAVENGER USED
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000294 *       OXF          OXYGEN IN FEEDWATER (DESIGN LIMIT OR ACTUAL)
000296 *       PAB          ABSOLUTE PRESSURE (PSIG + PATM)
000298 *       PABH         ABSOLUTE PRESSURE HIGH
000300 *       PABL         ABSOLUTE PRESSURE LOW
000302 *       PABT         ABSOLUTE PRESSURE IN TABLE
000304 *       PAFT         P ALKALINITY IN FEEDWATER BY TEST
000306 *       PATM         ATMOSPHERIC PRESSURE CORRECTED FOR ALTITUDE
000308 *       PBLR         OPERATING PRESSURE (PSIG) OF BOILER
000310 *       PDA          OPERATING PRESSURE (PSIG) OF DEAERATOR OR
000312 *                      DEAERATING HEATER
000314 *       PHBLR        PH OF BOILER WATER
000316 *       PHCR         PH OF CONDENSATE RETURN
000318 *       PHSBD        PHOSPHATE RESIDUAL IN BOILER BLOWDOWN
000320 *       PHSBDT       PHOSPHATE LEVEL IN BOILER BY TEST
000322 *       PHSN         TABLE NUMBER OF PHOSPHATE CHEMICAL USED
000324 *       PHSNHD       PHOSPHATE REQUIRED/1K GAL FW/PPM HD
000326 *       PHSNOH       NAOH REQUIRED/100 LBS PHOSPHATE CHEMICAL
000328 *       PHSPC        PERCENTAGE OF PO4 IN PHOSPHATE CHEMICAL
000330 *       PHS$         NAME OF PHOSPHATE CHEMICAL USED
000332 *       PHSW         WEIGHT OF PHOSPHATE CHEMICAL/DAY - AFP 91-41
000334 *       PHSWCAF      WEIGHT OF PHOSPHATE CHEMICAL FOR CALCIUM
000336 *       PHSWHD       WEIGHT OF PHOSPHATE CHEMICAL FOR TOTAL HARDNESS
000338 *       PHSWR        WEIGHT OF PHOSPHATE CHEMICAL FOR RESIDUAL
000340 *       QBD          BLOWDOWN (LB/HR)
000342 *       QCR          CONDENSATE RETURNED (LB/HR)
000344 *       QF           FEEDWATER (LB/HR)
000346 *       QL           STEAM + CONDENSATE LOSSES (LB/HR)
000348 *       QMU          MAKEUP (LB/HR)
000350 *       QMUC         CONSTRAINED MAKEUP (LB/HR) FOR COMPARISON TO
000352 *                      ACTUAL OPERATING SYSTEMS
000354 *       QMUSI        MAKEUP (LB/HR) BASED ON SILICA
000356 *       QMUTDS       MAKEUP (LB/HR) BASED ON TDS
000358 *       QMUTSS       MAKEUP (LB/HR) BASED ON TSS
000360 *       QS           ACTUAL STEAM CAPACITY INVESTIGATED (LB/HR)
000362 *       QSM          MAXIMUM EVAPORATION CAPACITY (LB/HR)
000364 *       RID$         RUN ID TO IDENTIFY DIFFERENT DATA FOR SAME
000366 *                      BOILER
000368 *       RS           RATED STEAM PRODUCTION OF BOILER (LB/HR)
000370 *       SIBD         LIMIT-SILICA IN BLOWDOWN
000372 *       SICR         SILICA IN CONDENSATE RETURN
000374 *       SIF          SILICA IN FEEDWATER BY CALCULATION
000376 *       SIFE         TOTAL SILICA IN FEEDWATER TO CALCULATE BLRSI
000378 *                      IN ADVANCED CALCULATIONS
000380 *       SIFT         SILICA IN FEEDWATER BY TEST
000382 *       SIMU         SILICA IN MAKEUP
000384 *       SINHD        SILICA NEEDED FOR HARDNESS
000386 *       SIS          SILICA IN STEAM
000388 *       SFBD         SULFITE RESIDUAL IN BOILER BLOWDOWN
000390 *       SFBDT        SULFITE LEVEL IN BOILER BY TEST
000392 *       SFPC         PURITY (%) OF SO3 IN SULFITE CHEMICAL
000394 *       SFW          WEIGHT OF SULFITE CHEMICAL USED PER DAY
000396 *       SFWOX(N)     WEIGHT OF SULFITE CHEMICAL FOR OXYGEN LEAKAGE
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000398 *                       (ITERATION)
000400 *       SFWR(N)      WEIGHT OF SULFITE CHEMICAL FOR RESIDUAL
000402 *                       (ITERATION)
000404 *       SODASHW      WEIGHT-SODA ASH (SODIUM CARBONATE) NEEDED TO
000406 *                       CONTROL CALCIUM IN ABSENCE OF PHOSPHATE
000408 *       TDSBD        LIMIT-TOTAL DISSOLVED SOLIDS IN BOILER BLOWDOWN
000410 *       TDSBDT       TOTAL DISSOLVED SOLIDS LEVEL IN BOILER BY TEST
000412 *       TDSCR        TOTAL DISSOLVED SOLIDS IN CONDENSATE RETURN
000414 *       TDSF         TOTAL DISSOLVED SOLIDS IN FEEDWATER BY
000416 *                       CALCULATION FOR COMPARISON TO TDSF
000418 *       TDSFE        TOTAL DISSOLVED SOLIDS IN FEEDWATER TO
000420 *                       CALCULATE BLRTDS IN ADVANCED CALCULATIONS
000422 *       TDSFT        TOTAL DISSOLVED SOLIDS IN FEEDWATER BY TEST
000424 *       TDSMU        TOTAL DISSOLVED SOLIDS IN MAKEUP
000426 *       TDSS         TOTAL DISSOLVED SOLIDS IN STEAM
000428 *       TF           OPERATING TEMPERATURE OF DEAERATING HEATER AND
000430 *                       FEEDWATER
000432 *       THCR         TOTAL HARDNESS IN CONDENSATE RETURN
000434 *       THF          TOTAL HARDNESS IN FEEDWATER
000436 *       THMU         TOTAL HARDNESS IN MAKEUP
000438 *       TSSBD        LIMIT-TOTAL SUSPENDED SOLIDS IN BOILER BLOWDOWN
000440 *       TSSCR        TOTAL SUSPENDED SOLIDS IN CONDENSATE RETURN
000442 *       TSSF         TOTAL SUSPENDED SOLIDS IN FEEDWATER
000444 *       TSSFE        TOTAL SUSPENDED SOLIDS IN FEEDWATER TO
000446 *                       CALCULATE BLRTSS IN ADVANCED CALCULATIONS
000448 *       TSSMU        TOTAL SUSPENDED SOLIDS IN MAKEUP
000450 *       UID$         COMPUTER USER ID
000452 *       V0$          PRETREATMENT VERIFICATION - FILTER
000454 *       V1$          PRETREATMENT VERIFICATION - SODIUM ZEOLITE
000456 *                       SOFTENER
000458 *       V2$          PRETREATMENT VERIFICATION - HYDROGEN ZEOLITE
000460 *                       SOFTENER
000462 *       V3$          PRETREATMENT VERIFICATION - SPLIT STREAM
000464 *                       SOFTENING - NAZ AND HZ
000466 *       V4$          PRETREATMENT VERIFICATION - ZEOLITE DEALKALIZER
000468 *       V5$          PRETREATMENT VERIFICATION - COLD LIME-SODA
000470 *                       SOFTENER
000472 *       V6$          PRETREATMENT VERIFICATION - HOT LIME-SODA
000474 *                       SOFTENER
000476 *       V7$          PRETREATMENT VERIFICATION - DEGASIFIER
000478 *       WARNXXX#$    WARNING TEXT STRING NUMBER #, XXX TEST ID
000480 *       Y$           DECISION VARIABLE, INITIALIZED TO QQ BEFORE
000482 *                       EACH DECISION IS MADE
000484 *       Z            DECISION VARIABLE, INITIALIZED TO ZERO BEFORE
000486 *                       EACH DECISION IS MADE
000488 *       Z$           DECISION VARIABLE, INITIALIZED TO QQ BEFORE
000490 *                       EACH DECISION IS MADE
000492 *
000494 ******     INITIALIZE VARIABLES TO ZERO AND SET GENERAL INFO
000496 * THE WANG VS 100 COMPUTER AUTOMATICALLY INITIALIZES ALL
000498 *     VARIABLES TO ZERO
000500 *
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000502 COM AMSL,HG,PAB,PATM,PBLR,UID$ 3,IPLVOL$ 6,DEEDATAVOL$ 6
000504 DIM DATE$ 6,BASEID$ 3,BLDG$ 7,BLR$ 2,RID$ 2,                          !
000506 BASE$ 20,OPR$ 15,PHS$ 40,V0$ 1,V1$ 1,V2$ 1,V3$ 1,V4$ 1,V5$ 1,        !
000508 V6$ 1,V7$ 1,OTHAM$ 40,OTHLSN$ 40,OTHOH$ 40,OTHPHS$ 40,OTHSF$ 40,     !
000510 COMMENT$ 45
000512 *
000514 CALL "EXTRACT" ADDR("ID",UID$,"XV",IPLVOL$)
000516 IVARDATA : FMT POS(104),CH(06),POS(138),CH(06)
000518 LYT1 : FMT CH(3),CH(6),CH(3),CH(7),CH(2),CH(2),                        !
000520 PIC(#####),CH(20),                                                     !
000522 4*PIC(####.##),                                                        !
000524 2*PIC(####.##),                                                        !
000526 6*PIC(####.##),                                                        !
000528 2*PIC(####.##),CH(15),PIC(###.####),                                   !
000530 6*PIC(####.##),2*PIC(###.####),CH(40),                                 !
000532 3*PIC(#######.##),7*PIC(####.##),                                      !
000534 8*PIC(####.##),                                                        !
000536 5*PIC(####.##),PIC(###.####),                                          !
000538 8*CH(1),                                                               !
000540 4*PIC(####.##),                                                        !
000542 4*PIC(####.##),                                                        !
000544 6*PIC(####.##),                                                        !
000546 5*PIC(###.##),                                                         !
000548 5*CH(40),CH(45)
000550 LYT2 : FMT POS(4),CH(6)
000552 *
000554 SELECT #1,"ESTM",INDEXED,RECSIZE=826,KEYPOS=1,KEYLEN=23
000556 SELECT #2,"IVAR",INDEXED,RECSIZE=2000,KEYPOS=1,KEYLEN=1
000558 OPEN NODISPLAY #2,SHARED,FILE="IVAR    ",LIBRARY="I1XXDATA",          !
000560 VOLUME=IPLVOL$
000562 READ #2, KEY > " "
000564 GET #2,USING IVARDATA,DEEDATAVOL$
000566 SELECT PAUSE 10
000568 START1 : Z=0
000570 ACCEPT                                                                 !
000572 AT(1,5),  "**************************************************",!
000574 AT(2,5),  "**      STEAM BOILER WATER TREATMENT PROGRAM      **",!
000576 AT(3,5),  "**                                                **",!
000578 AT(4,5),  "**    WRITTEN BY MAJOR MICHAEL J.W. KAMINSKAS     **",!
000580 AT(5,5),  "**         AIR COMMAND AND STAFF COLLEGE          **",!
000582 AT(6,5),  "**             MAXWELL AFB AL 36112               **",!
000584 AT(7,5),  "**                 FEBRUARY 1988                  **",!
000586 AT(8,5),  "**  DIRECT COMMENTS TO HQ AFESC/DEMM AV 523-6351   **",!
000588 AT(9,5),  "**                  OR AFIT/DEE      AV 785-4552  **",!
000590 AT(10,5), "**************************************************",!
000592 AT(12,2), "ENTER    FOR ACTION",                                       !
000594 AT(13,2), "-----    ----------",                                       !
000596 AT(14,2), "  1      BOILER AND TREATMENT DATA FILE",                   !
000598 AT(15,2), "  3      AFP 91-41 DOSAGE CALCULATIONS AND",                !
000600 AT(16,2), "           BASIC SYSTEM AND TREATMENT ANALYSIS",            !
000602 AT(17,2), "  5      ESTIMATED TREATMENT STABILITY POINT AND",          !
000604 AT(18,2), "           ADVANCED TREATMENT ANALYSIS",                    !
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000606 AT(19,2), " 16      EXIT FROM PROGRAM",                          !
000608 AT(21,5), "ACTION NUMBER", FAC(HEX(91)), Z, PIC(##), KEYS(BIN(0))
000610 IF Z = 16 THEN GOTO EXIT1
000612 IF Z = 1 THEN GOSUB INPUT1
000614 IF Z = 3 THEN CALL "CALCP"
000616 IF Z = 5 THEN CALL "CALCS"
000618 GOTO START1 : REM THE ONLY WAY TO EXIT PROGRAM IS THROUGH Z = 16 !
000620                 ON MENU
000622 EXIT1 : CLOSE #2 : END
000624 *
000626 INPUT1:
000628 *
000630 * BEGIN SUBROUTINE TO INPUT DATA TO FILE AND PROGRAMS
000632 START2 : Z = 0
000634 ACCEPT                                                           !
000636 AT(2,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
000638 AT(4,2), "BOILER AND TREATMENT DATA FILE",                        !
000640 AT(5,2), "ENTER    FOR ACTION",                                  !
000642 AT(6,2), "-----    ----------",                                  !
000644 AT(7,2), "  1      CREATE NEW DATA RECORD",                      !
000646 AT(8,2), "  3      UPDATE EXISTING DATA RECORD",                 !
000648 AT(9,2), "  5      DELETE EXISTING DATA RECORD",                 !
000650 AT(10,2)," 16      RETURN TO PREVIOUS MENU",                     !
000652 AT(14,2)," 21      CREATE NEW DATA FILE - RUN ONLY ONCE",        !
000654 AT(16,5),"ACTION NUMBER", FAC(HEX(91)), Z, PIC(##), KEYS(BIN(0))
000656 IF Z = 16 THEN GOTO EXIT2
000658 IF Z = 1 THEN GOSUB INPUT2
000660 IF Z = 3 THEN GOSUB INPUT3
000662 IF Z = 5 THEN GOSUB INPUT4
000664 IF Z = 21 THEN GOSUB CREATE1
000666 GOTO START2
000668 EXIT2 : RETURN: REM SUBROUTINE INPUT1 ENDS
000670 *
000672 CREATE1:
000674 *
000676 * BEGIN SUBROUTINE TO CREATE THE DATA FILE - NEED ONLY BE DONE
000678 *   ONCE ON THE SYSTEM
000680 DATE$ = DATE
000682 OPEN NODISPLAY #1, OUTPUT,FILE="ESTM",LIBRARY="EIXXDATA",         !
000684 VOLUME=DEEDATAVOL$,SPACE=100
000686 PRINT : PRINT : PRINT "DATA FILE CREATED!" : PRINT : PRINT
000688 PUT #1 USING  LYT2, DATE$ : WRITE #1 : CLOSE #1 : RETURN
000690 REM SUBROUTINE CREATE1 ENDS
000692 *
000694 INPUT2:
000696 *
000698 * BEGIN SUBROUTINE TO CREATE NEW DATA RECORD
000700 DATE$ = DATE
000702 OPEN NODISPLAY #1, SHARED,FILE="ESTM",LIBRARY="EIXXDATA",         !
000704 VOLUME=DEEDATAVOL$,SPACE=100
000706 ACCEPT                                                           !
000708 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
```

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000710 AT(3,1), "THIS SCREEN ASKS FOR A RECORD NAME (KEYFIELD) TO DESIGN!
000712 ATE THE DATA RECORD",                                              !
000714 AT(4,3), "BEING CREATED.  ALL DATA REQUESTED IS NEEDED TO UNIQUEL!
000716 Y DESCRIBE THIS RECORD.",                                          !
000718 AT(6,5), "COMPUTER USER ID  (EG. I1K)  ",UID$,CH(3),               !
000720 AT(7,5), "TODAY'S DATE      (YYMMDD)   ",DATE$,CH(6),              !
000722 AT(8,5), "BASE ID           (EG. MAX)  ",BASEID$,CH(3),            !
000724 AT(9,5), "BUILDING NUMBER   (EG. 1402) ",BLDG$,CH(7),              !
000726 AT(10,5),"BOILER DESIGNATOR (EG. 4)    ",BLR$,CH(2),              !
000728 AT(11,5),"RUN INDICATOR                ",RID$,CH(2),              !
000730 AT(12,5),"  (EG. A=ACTUAL CONDITIONS, I=IDEAL CONDITIONS,",        !
000732 AT(13,5),"       S=SOFTENER, LL=LOW LOSS, PC=PURE CONDENSATE)",    !
000734 AT(15,1),"PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
000736 GOSUB SYSTEM
000738 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB OPERATIONS
000740 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB ALTITUDE
000742 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB DEAERATOR
000744 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB PRETREATMENT
000746 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB MAKEUP
000748 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB CONDENSATE
000750 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB FEEDWATER
000752 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB BOILER
000754 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB STEAM
000756 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB DISSOLVED
000758 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB SILICA
000760 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB PHOSPHATE
000762 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB HYDROXYL
000764 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB BREAKDOWN
000766 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB LIGNOSULFONATE
000768 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB SULFITE
000770 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB AMINE
000772 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB DISTRIBUTION
000774 IF Y$ = "E" THEN GOTO 784    ELSE GOSUB DOSAGE
000776 *
000778 * SEE LYT1 FOR FORMAT OF PUT #1 STATEMENT BELOW.  VARIABLES AND
000780 *   FORMATS ALIGN BY ROWS.
000782 *
000784 PUT #1 USING LYT1 , UID$,DATE$,BASEID$,BLDG$,BLR$,RID$,            !
000786 AMSL,BASE$,                                                        !
000788 CACR,CAMU,CARBPC,CHAPC,                                            !
000790 LSNBD,LSNPC,                                                       !
000792 MACR,MAFT,MAMU,MGCR,MGMU,MORPC,                                    !
000794 NAOHPC,OHBDT,OPR$,OXF,                                             !
000796 PAFT,PBLR,PDA,PHBLR,PHSBD,PHSPC,PHSNHD,PHSNOH,PHS$,                !
000798 QL,QS,RS,SIBD,SICR,SIFT,SIMU,SIS,SFBD,SFPC,                        !
000800 TDSBD,TDSCR,TDSFT,TDSMU,TDSS,TF,TSSCR,TSSMU,                       !
000802 CUCR,FECR,PHCR,THCR,THMU,DENSF,                                    !
000804 V0$,V1$,V2$,V3$,V4$,V5$,V6$,V7$,                                   !
000806 CAFT,CHADR,MORDR,OHBD,                                             !
000808 LSNBDT,PHSBDT,SFBDT,TDSBDT,                                        !
000810 LBCHA,LBLSN,LBMOR,LBOH,LBPHS,LBSF,                                 !
000812 LBOTHAM,LBOTHLSN,LBOTHOH,LBOTHPHS,LBOTHSF,                         !
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000814 OTHAM$,OTHLSN$,OTHOH$,OTHPHS$,OTHSF$,COMMENT$
000816 WRITE #1 : CLOSE #1 : RETURN : REM SUBROUTINE INPUT2 ENDS
000818 *
000820 SYSTEM:
000822 *
000824 * SUBROUTINE TO LABEL SYSTEM INFORMATION
000826 START3 : ACCEPT                                                    !
000828 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
000830 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",   !
000832 AT(5,5), "INSTALLATION (EG. XXXX AFB)   ",BASE$, CH(20),          !
000834 AT(6,5), "LAST NAME    (EG. YOURS)      ",OPR$, CH(15),           !
000836 AT(7,1), "COMMENT DESCRIBING THIS DATA  ",COMMENT$, CH(45),       !
000838 AT(10,1),"**    NOTE - IF EXITING, ALL DATA ENTERED TO THAT POINT!
000840  WILL BE SAVED!    **", KEYS(BIN(0)) : PRINT
000842 DEC1 : Y$ = "QQ"
000844 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
000846 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT3
000848 IF Y$ = "N" THEN GOTO START3  ELSE GOTO DEC1
000850 EXIT3 : RETURN : REM SUBROUTINE SYSTEM ENDS
000852 *
000854 OPERATIONS:
000856 *
000858 * SUBROUTINE TO GATHER SYSTEM OPERATION INFORMATION
000860 ACCEPT                                                            !
000862 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
000864 AT(3,15), "************************" ,                            !
000866 AT(4,15), "*       WARNING        *" ,                            !
000868 AT(5,15), "*  DO NOT USE COMMAS   *" ,                            !
000870 AT(6,15), "* IN NUMERICAL INPUTS  *" ,                            !
000872 AT(7,15), "************************" ,                            !
000874 AT(9,1), "NOTE - CONDUCTIVITY IS NOT AN INPUT ANYWHERE IN THIS PR!
000876 OGRAM.  THE RELATIONSHIP ",                                       !
000878 AT(10,1),"BETWEEN CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IS NOT  !
000880 A FIXED RATIO.  AFP 91-41",                                       !
000882 AT(11,1),"DOES USE AN APPROXIMATION HOWEVER.  HIGHLY RECOMMEND SA!
000884 MPLES BE TESTED FOR      ",                                       !
000886 AT(12,1),"CONDUCTIVITY, TOTAL DISSOLVED SOLIDS, AND TOTAL SUSPEND!
000888 ED SOLIDS TWICE A YEAR.  ",                                       !
000890 AT(13,1),"THE BASE FUELS LAB CAN PERFORM THE LATTER TWO TESTS.  T!
000892 HEN DETERMINE THE        ",                                       !
000894 AT(14,1),"TOTAL DISSOLVED SOLIDS/CONDUCTIVITY RATIO FOR EACH SAMP!
000896 LE.  ONCE THE RATIO IS   ",                                       !
000898 AT(15,1),"FOUND THE BOILER CAN BE OPERATED ON A CONDUCTIVITY LIMI!
000900 T THAT RELATES TO THE    ",                                       !
000902 AT(16,1),"TOTAL DISSOLVED SOLIDS LIMIT WITH GREAT CONFIDENCE.  TH!
000904 E SAMPLE USED MUST BE AS ",                                       !
000906 AT(17,1),"CLOSE AS POSSIBLE TO THE FINAL OPERATING POINT.  ADJUST!
000908  TREATMENT AND RERUN     ",                                       !
000910 AT(18,1),"THESE TESTS UNTIL THE DESIRED OPERATING POINT IS REACHE!
000912 D.                       ",                                       !
000914 AT(22,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
000916 ACCEPT                                                            !
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000918 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    !
000920 AT(3,1), "OTHER SOURCES OF THE DATA NEEDED FOR THIS PROGRAM ARE A!
000922 S FOLLOWS:                ",                                        !
000924 AT(5,1), "MAKEUP WATER QUALITY - AF FORM 2752, ENVIRONMENTAL SAMP!
000926 LING DATA                 ",                                        !
000928 AT(6,3), "HOSPITAL BIOENVIRONMENTAL ENGINEER",                      !
000930 AT(7,3), "CE ENVIRONMENTAL SUPPORT SHOP (WATER + WASTE)",           !
000932 AT(8,3), "LOCAL WATER UTILITY - DIFFERENT FORM",                    !
000934 AT(9,3), "AFESC CORROSION ANALYSIS REPORT - DIFFERENT FORM",        !
000936 AT(10,1),"SYSTEM OPERATION - AF FORM 1464, MONTHLY STEAM BOILER P!
000938 LANT OPERATING LOG        ",                                        !
000940 AT(11,3),"HEAT SHOP OR CENTRAL HEATING PLANT AS APPROPRIATE",       !
000942 AT(12,1),"BOILER WATER TESTS - AF FORM 1459, WATER TREATMENT OPER!
000944 ATING LOG FOR STEAM AND ",                                          !
000946 AT(13,2),"HOT WATER BOILERS",                                       !
000948 AT(14,3),"HEAT SHOP OR CENTRAL HEATING PLANT AS APPROPRIATE",       !
000950 AT(16,1),"THE BASE FUELS LAB IS THE ONLY FUNCTION ON BASE THAT CA!
000952 N READILY PERFORM THE   ",                                          !
000954 AT(17,1),"THE TOTAL DISSOLVED SOLIDS AND TOTAL SUSPENDED SOLIDS T!
000956 ESTS!                     ",                                        !
000958 AT(19,1),"ALL OTHER TESTS CAN BE PERFORMED WITH EQUIPMENT AND REA!
000960 GENTS AVAILABLE UNDER   ",                                          !
000962 AT(20,1),"THE AFESC CENTRAL LABORATORY CONTRACT.  THESE ITEMS ARE!
000964  FREE TO ANY BASE UPON  ",                                          !
000966 AT(21,1),"REQUEST.",                                                !
000968 AT(24,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
000970 ACCEPT                                                              !
000972 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    !
000974 AT(3,1), "FOR ACCURATE TESTING, ACCURATE SAMPLING MUST BE DONE!",!
000976 AT(5,1), "THE FOLLOWING RULES WILL ENSURE A GOOD START.",           !
000978 AT(7,3), "1.  REVIEW PARA. 6-6, METHODS OF SAMPLING, IN AFP 91-41!
000980 .",                                                                 !
000982 AT(8,3), "2.  ALWAYS USE A SAMPLE COOLER WHENEVER THE SOURCE IS A!
000984 T PRESSURE AND OVER  ",                                             !
000986 AT(9,3), "100 DEGREES FAHRENHEIT.",                                 !
000988 AT(10,3),"3.  FILL SAMPLING CONTAINER ABOUT 1/8TH FULL OR LESS AN!
000990 D CAP.  AGITATE WELL ",                                             !
000992 AT(11,3),"    AND DRAIN.  REPEAT TWO TIMES TO FULLY PREPARE THE C!
000994 ONTAINER.             ",                                            !
000996 AT(12,3),"4.  DO NOT USE A SAMPLING CONTAINER CONTAMINATED OR CON!
000998 TAINING ANY ITEM TO  ",                                             !
001000 AT(13,3),"    BE TESTED.  THAT IS, NO GLASS IF SILICA IS BEING TE!
001002 STED OR COPPER IF    ",                                             !
001004 AT(14,3),"    COPPER IS OF INTEREST.  FOR MOST TESTING PLASTIC IS!
001006  BEST.                ",                                           !
001008 AT(15,3),"5.  RUN THE SAMPLE WATER LONG ENOUGH TO FLUSH THE SAMPL!
001010 ING LINE AND COOLER  ",                                             !
001012 AT(16,3),"    AND GET A REPRESENTATIVE SAMPLE FROM THE SOURCE.", !
001014 AT(17,3),"6.  EXTEND THE SAMPLE LINE TO THE BOTTOM OF THE SAMPLE !
001016 CONTAINER USING       ",                                           !
001018 AT(18,3),"    PLASTIC TUBING, PREFERABLY TYGON.  RUN THE SAMPLE T!
001020 O OVERFLOW THE SAMPLE",                                             !
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001022 AT(19,3),"    CONTAINER AT LEAST TWO CONTAINER VOLUMES AND CAP.",!
001024 AT(22,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
001026 START4 : ACCEPT                                                  !
001028 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
001030 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
001032 AT(5,15), "**     STEAM PRODUCTION DATA     **",                 !
001034 AT(7,8),  "***  THIS PROGRAM IS DESIGNED FOR USE WITH A  ***",   !
001036 AT(8,8),  "SINGLE BOILER.  IF ANALYZING A MULTIBOILER PLANT,",    !
001038 AT(9,8),  "PROPORTION THE TOTAL PLANT MASSFLOW TO JUST ONE",      !
001040 AT(10,8), "BOILER.  THUS, ANALYZE EACH BOILER SEPARATELY.",       !
001042 AT(11,28),                    "***",                             !
001044 AT(13,1),"OPERATING GAUGE PRESSURE OF BOILER              = ",    !
001046 PBLR,PIC(####.##),                                               !
001048 AT(15,1),"RATED STEAM PRODUCTION (POUNDS/HOUR) OF BOILER         !
001050  =",RS, PIC(########.##),                                        !
001052 AT(17,1),"ACTUAL STEAM PRODUCTION INVESTIGATED (POUNDS/HOUR QS)  !
001054  =",QS, PIC(########.##),                                        !
001056 AT(19,1),"ESTIMATED LOSSES STEAM AND CONDENSATE (POUNDS/HOUR QL) !
001058  =",QL, PIC(########.##),                                        !
001060 AT(20,1),"NOTE THAT GOOD PRACTICE IS TO KEEP QL AS SMALL AS POSSI!
001062 BLE BASED UPON STEAM USE!",                                      !
001064 AT(21,1),"ALSO NOTE - AFP 91-41 ASSUMES NO LOSSES IN ITS CALCULAT!
001066 IONS!", KEYS(BIN(0)) : PRINT
001068 IF QS <= 0 THEN GOTO 1070   ELSE GOTO 1074
001070 PRINT "STEAM PRODUCTION CANNOT BE ZERO" : PRINT : PRINT · PRINT :!
001072 GOTO 1026
001074 DEC4 : Y$ = "QQ"
001076 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001078 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT4
001080 IF Y$ = "N" THEN GOTO START4  ELSE GOTO DEC4
001082 EXIT4 : RETURN : REM SUBROUTINE OPERATIONS ENDS
001084 *
001086 ALTITUDE:
001088 *
001090 * SUBROUTINE TO DETERMINE ALTITUDE AT WHICH BOILER IS OPERATING
001092 DEC5 : Y$ = "QQ" : PRINT
001094 INPUT "DO YOU KNOW ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL ( Y OR!
001096  N ) ",Y$
001098 IF Y$ = "Y" THEN GOTO 1102
001100 IF Y$ = "N" THEN GOTO 1108   ELSE GOTO DEC5
001102 PRINT
001104 INPUT "ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL (FT) =",AMSL
001106 RETURN
001108 START5 : Y$ = "QQ"
001110 ACCEPT                                                           !
001112 AT(1,5),"          ALTITUDE FOR LISTED INSTALLATIONS",           !
001114 AT(2,5),"              FEET ABOVE MEAN SEA LEVEL",               !
001116 AT(3,5), "ALTUS AFB OK          1376  EGLIN AFB FL            85",!
001118 AT(4,5), "ANDERSEN AFB GUAM      525  EIELSON AFB AK         534",!
001120 AT(5,5), "ANDREWS AFB MD         279  ELLSWORTH AFB SD      3200",!
001122 AT(6,5), "ARNOLD AFS TN    950-1150  ELMENDORF AFB AK        118",!
001124 AT(7,5), "BARKSDALE AFB LA       166  ENGLAND AFB LA          89",!
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001126 AT(8,5), "BEALE AFB CA          113  FAIRCHILD AFB WA      2462",!
001128 AT(9,5), "BERGSTROM AFB TX      541  F.E. WARREN AFB WY    6142",!
001130 AT(10,5),"BLYTHEVILLE AFB AR    254  GEORGE AFB CA         2875",!
001132 AT(11,5),"BOLLING AFB DC         16  GOODFELLOW AFB TX     1877",!
001134 AT(12,5),"BROOKS AFB TX         600  GRAND FORKS AFB ND     911",!
001136 AT(13,5),"CANNON AFB NM        4295  GRIFFISS AFB NY         504",!
001138 AT(14,5),"CARSWELL AFB TX       650  GRISSOM AFB IN          800",!
001140 AT(15,5),"CASTLE AFB CA         188  GUNTER AFS AL           220",!
001142 AT(16,5),"CHANUTE AFB IL        735  HANSCOM AFB MA         133",!
001144 AT(17,5),"CHARLESTON AFB SC      45  HICKAM AFB HI             0",!
001146 AT(18,5),"COLUMBUS AFB MS       214  HILL AFB UT            4788",!
001148 AT(19,5),"DAVIS-MONTHAN AFB AZ 2620  HOLLOMAN AFB NM        4093",!
001150 AT(20,5),"DOVER AFB DE           28  HOMESTEAD AFB FL          7",!
001152 AT(21,5),"DYESS AFB TX         1789  HURLBURT FLD FL          35",!
001154 AT(22,5),"EDWARDS AFB CA       2302  INDIAN SPRINGS FLD NV 3124",!
001156 AT(23,1),"IS YOUR BASE LISTED ABOVE ( Y OR N ) ",Y$, CH(1),      !
001158 KEYS(BIN(0))
001160 IF Y$ = "Y" THEN GOTO 1164
001162 IF Y$ = "N" THEN GOTO START7  ELSE GOTO START5
001164 INPUT "ALTITUDE = ",AMSL
001166 DEC6 : Y$ = "QQ"
001168 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001170 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT6
001172 IF Y$ = "N" THEN GOTO START5  ELSE GOTO DEC6
001174 EXIT6 : RETURN : REM SUBROUTINE ALTITUDE ENDS
001176 START7 : Y$ = "QQ"
001178 ACCEPT                                                    !
001180 AT(1,5), "KEESLER AFB MS         26  MOODY AFB GA           233",!
001182 AT(2,5), "KELLY AFB TX          689  MOUNTAIN HOME AFB ID  3000",!
001184 AT(3,5), "KIRTLAND AFB NM      5352  MYRTLE BEACH AFB SC     25",!
001186 AT(4,5), "K.I. SAWYER AFB MI   1220  NELLIS AFB NV          2171",!
001188 AT(5,5), "LACKLAND AFB TX       787  NORTON AFB CA          1156",!
001190 AT(6,5), "LANGLEY AFB VA         10  OFFUTT AFB NE          1048",!
001192 AT(7,5), "LAUGHLIN AFB TX      1080  PATRICK AFB FL            9",!
001194 AT(8,5), "LITTLE ROCK AFB AR    310  PEASE AFB NH           101",!
001196 AT(9,5), "LORING AFB ME         746  PETERSON AFB CO        6200",!
001198 AT(10,5),"LOS ANGELES AFS CA     95  PLATTSBURGH AFB NY     235",!
001200 AT(11,5),"LOWRY AFB CO         5400  POPE AFB NC            218",!
001202 AT(12,5),"LUKE AFB AZ          1101  RANDOLPH AFB TX        761",!
001204 AT(13,5),"MACDILL AFB FL          6  REESE AFB TX          3338",!
001206 AT(14,5),"MALMSTROM AFB MT     3525  ROBINS AFB GA           294",!
001208 AT(15,5),"MARCH AFB CA         1530  SCOTT AFB IL           453",!
001210 AT(16,5),"MATHER AFB CA          96  SEYMOUR JOHNSON AFB NC 109",!
001212 AT(17,5),"MAXWELL AFB AL        168  SHAW AFB SC            244",!
001214 AT(18,5),"MCCHORD AFB WA        322  SHEMYA AFB AK          270",!
001216 AT(19,5),"MCCLELLAN AFB CA       76  SHEPPARD AFB TX       1015",!
001218 AT(20,5),"MCCONNELL AFB KS     1371  TINKER AFB OK         1291",!
001220 AT(21,5),"MCGUIRE AFB NJ        133  TRAVIS AFB CA           62",!
001222 AT(22,5),"MINOT AFB ND         1650  TYNDALL AFB FL           18",!
001224 AT(23,1),"IS YOUR BASE LISTED ABOVE ( Y OR N ) ",Y$, CH(1),      !
001226 KEYS(BIN(0))
001228 IF Y$ = "Y" THEN GOTO 1232
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001230 IF Y$ = "N" THEN GOTO START8  ELSE GOTO START7
001232 INPUT "ALTITUDE = ",AMSL
001234 DEC7 : Y$ = "QQ"
001236 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001238 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT7
001240 IF Y$ = "N" THEN GOTO START7  ELSE GOTO DEC7
001242 EXIT7 : RETURN : REM SUBROUTINE ALTITUDE ENDS
001244 START8 : Y$ = "QQ"
001246 ACCEPT                                                          !
001248 AT(1,5), "US AIR FORCE ACADEMY 7280  WHITEMAN AFB MO        869",!
001250 AT(2,5), "VANCE AFB OK         1307  WILLIAMS AFB AZ       1385",!
001252 AT(3,5), "VANDENBERG AFB CA     400  WRIGHT-PATTERSON AFB   824",!
001254 AT(4,5), "WHEELER AFB HI        845  WURTSMITH AFB MI       634",!
001256 AT(6,5), "              THIS IS THE LAST LIST!",                 !
001258 AT(8,1), "WOULD YOU LIKE TO RERUN THE LIST ( Y OR N ) ",Y$,CH(1),!
001260 KEYS(BIN(0)) : PRINT
001262 IF Y$ = "Y" THEN GOTO START5
001264 IF Y$ = "N" THEN GOTO 1266   ELSE GOTO START8
001266 INPUT "ALTITUDE (EITHER ABOVE OR BEST GUESS) =",AMSL : PRINT
001268 DEC8 : Y$ = "QQ"
001270 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001272 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT8
001274 IF Y$ = "N" THEN GOTO START8  ELSE GOTO DEC8
001276 EXIT8 : RETURN : REM SUBROUTINE ALTITUDE ENDS
001278 *
001280 DEAERATOR:
001282 *
001284 * SUBROUTINE TO DETERMINE DEAERATING HEATER/DEAERATOR OPERATING
001286 *   INPUTS
001288 START9 : ACCEPT                                                 !
001290 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                 !
001292 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
001294 AT(5,15),"**     DEAERATING HEATER DATA     **",                 !
001296 AT(7,1), "OPERATING TEMPERATURE OF DEAERATING HEATER (DEG F)     !
001298 =",TF, PIC(####.##),                                            !
001300 AT(8,1), "OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG)   !
001302 =",PDA, PIC(####.##),                                           !
001304 AT(10,2),"* DESIGN LIMITATION - MECHANICAL LEAKAGE OF OXYGEN *", !
001306 AT(11,2),"                                        DESIGN EFFLUENT",!
001308 AT(12,2),"                                             OXYGEN    ",!
001310 AT(13,2),"    TYPE            PSIG     TEMP(F)      (PPM O2)",   !
001312 AT(14,2),"OPEN HEATER          0       160-210      0.5-1.0",    !
001314 AT(15,2),"DEAERATING HEATER   1-15      215-250        0.04",     !
001316 AT(16,2),"DEAERATOR           1-15      215-250        0.007",    !
001318 AT(18,1),"OXYGEN (PPM O2) IN 'DEAERATING HEATER' EFFLUENT =",OXF,!
001320 PIC(###.####), KEYS(BIN(0)) : PRINT
001322 IF TF < 150 OR TF > 260 THEN GOTO 1324    ELSE GOTO 1328
001324 PRINT "FEEDWATER/DEAERATING HEATER TEMPERATURE IS OUT OF RANGE" :!
001326 PRINT : PRINT : GOTO 1288
001328 IF PDA <> 0.0 AND PDA <> 0.5 THEN GOTO 1330    ELSE GOTO 1374
001330 IF PDA <> 1.0 AND PDA <> 1.5 THEN GOTO 1332    ELSE GOTO 1374
001332 IF PDA <> 2.0 AND PDA <> 2.5 THEN GOTO 1334    ELSE GOTO 1374
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001334 IF PDA <> 3.0 AND PDA <> 3.5 THEN GOTO 1336    ELSE GOTO 1374
001336 IF PDA <> 4.0 AND PDA <> 4.5 THEN GOTO 1338    ELSE GOTO 1374
001338 IF PDA <> 5.0 AND PDA <> 5.5 THEN GOTO 1340    ELSE GOTO 1374
001340 IF PDA <> 6.0 AND PDA <> 6.5 THEN GOTO 1342    ELSE GOTO 1374
001342 IF PDA <> 7.0 AND PDA <> 7.5 THEN GOTO 1344    ELSE GOTO 1374
001344 IF PDA <> 8.0 AND PDA <> 8.5 THEN GOTO 1346    ELSE GOTO 1374
001346 IF PDA <> 9.0 AND PDA <> 9.5 THEN GOTO 1348    ELSE GOTO 1374
001348 IF PDA <> 10.0 AND PDA <> 10.5 THEN GOTO 1350    ELSE GOTO 1374
001350 IF PDA <> 11.0 AND PDA <> 11.5 THEN GOTO 1352    ELSE GOTO 1374
001352 IF PDA <> 12.0 AND PDA <> 12.5 THEN GOTO 1354    ELSE GOTO 1374
001354 IF PDA <> 13.0 AND PDA <> 13.5 THEN GOTO 1356    ELSE GOTO 1374
001356 IF PDA <> 14.0 AND PDA <> 14.5 THEN GOTO 1358    ELSE GOTO 1374
001358 IF PDA <> 15.0 AND PDA <> 15.5 THEN GOTO 1360    ELSE GOTO 1374
001360 IF PDA <> 16.0 AND PDA <> 16.5 THEN GOTO 1362    ELSE GOTO 1374
001362 IF PDA <> 17.0 AND PDA <> 17.5 THEN GOTO 1364    ELSE GOTO 1374
001364 IF PDA <> 18.0 AND PDA <> 18.5 THEN GOTO 1366    ELSE GOTO 1374
001366 IF PDA <> 19.0 AND PDA <> 19.5 THEN GOTO 1368    ELSE GOTO 1374
001368 IF PDA = 20.0 THEN GOTO 1374
001370 PRINT "DEAERATING HEATER PRESSURE OF 0.0 TO 20.0 IN INCREMENTS OF!
001372  0.5 IS ACCEPTABLE" : PRINT : PRINT : GOTO 1288
001374 IF OXF < 0.007 OR OXF > 10 THEN GOTO 1376    ELSE GOTO 1380
001376 PRINT "OXYGEN IN FEEDWATER IS OUT OF RANGE" : PRINT : PRINT :    !
001378 GOTO 1288
001380 DEC9 : Y$ = "QQ"
001382 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001384 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT9
001386 IF Y$ = "N" THEN GOTO START9  ELSE GOTO DEC9
001388 EXIT9 : RETURN : REM SUBROUTINE DEAERATOR ENDS
001390 *
001392 PRETREATMENT:
001394 *
001396 * SUBROUTINE TO IDENTIFY PRETREATMENT USED ON MAKEUP FOR BOILER
001398 START10 : ACCEPT                                                    !
001400 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    !
001402 AT(3,1), "INDICATE  A 'Y' FOR ALL PRETREATMENT THAT APPLIES",       !
001404 AT(4,1), "          PRESS <ENTER> WHEN DONE",                      !
001406 AT(6,5), "FILTER                          ",V0$, CH(1),            !
001408 AT(7,5), "SODIUM ZEOLITE SOFTENER         ",V1$, CH(1),            !
001410 AT(8,5), "HYDROGEN ZEOLITE SOFTENER       ",V2$, CH(1),            !
001412 AT(9,5), "SPLIT STREAM SOFTENING          ",V3$, CH(1),            !
001414 AT(10,5),"ZEOLITE DEALKALIZER             ",V4$, CH(1),            !
001416 AT(11,5),"COLD LIME-SODA SOFTENER         ",V5$, CH(1),            !
001418 AT(12,5),"HOT LIME-SODA SOFTENER          ",V6$, CH(1),            !
001420 AT(13,5),"DEGASIFIER                      ",V7$, CH(1),            !
001422 KEYS(BIN(0))
001424 IF V0$ <> " " AND V0$ <> "Y" THEN GOTO START10
001426 IF V1$ <> " " AND V1$ <> "Y" THEN GOTO START10
001428 IF V2$ <> " " AND V2$ <> "Y" THEN GOTO START10
001430 IF V3$ <> " " AND V3$ <> "Y" THEN GOTO START10
001432 IF V4$ <> " " AND V4$ <> "Y" THEN GOTO START10
001434 IF V5$ <> " " AND V5$ <> "Y" THEN GOTO START10
001436 IF V6$ <> " " AND V6$ <> "Y" THEN GOTO START10
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001438 IF V7$ <> " " AND V7$ <> "Y" THEN GOTO START10
001440 DEC10 : PRINT : Y$ = "QQ"
001442 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001444 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT10
001446 IF Y$ = "N" THEN GOTO START10 ELSE GOTO DEC10
001448 EXIT10 : RETURN : REM SUBROUTINE PRETREATMENT ENDS
001450 *
001452 MAKEUP:
001454 *
001456 * SUBROUTINE TO INPUT MAKEUP QUALITY AFTER PRETREATMENT
001458 START11 : ACCEPT                                                    :
001460 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    :
001462 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",   :
001464 AT(5,2), "**     MAKEUP WATER QUALITY OF INTEREST     **",          :
001466 AT(6,2), "**          AFTER ALL PRETREATMENT          **",          :
001468 AT(8,3), " A * IN FRONT OF THE ITEM INDICATES IT AS A",             :
001470 AT(9,3), "   REGULAR TEST PERFORMED PER AFP 91-41",                 :
001472 AT(11,5)," TOTAL HARDNESS          (PPM CACO3) ",THMU,              :
001474 PIC(####.##),                                                       :
001476 AT(12,5),"* CALCIUM HARDNESS       (PPM CACO3) ",CAMU,              :
001478 PIC(####.##),                                                       :
001480 AT(13,5)," MAGNESIUM HARDNESS      (PPM CACO3) ",MGMU,              :
001482 PIC(####.##),                                                       :
001484 AT(14,5),"* M ALKALINITY           (PPM CACO3) ",MAMU,              :
001486 PIC(####.##),                                                       :
001488 AT(15,5),"* TOTAL DISSOLVED SOLIDS (PPM)       ",TDSMU,            :
001490 PIC(####.##),                                                       :
001492 AT(16,5)," SILICA                  (PPM SIO2)  ",SIMU,              :
001494 PIC(####.##),                                                       :
001496 AT(17,5)," TOTAL SUSPENDED SOLIDS (PPM)       ",TSSMU,             :
001498 PIC(####.##), KEYS(BIN(0)) : PRINT
001500 DEC11 : Y$ = "QQ"
001502 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001504 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT11
001506 IF Y$ = "N" THEN GOTO START11  ELSE GOTO DEC11
001508 EXIT11 : RETURN : REM SUBROUTINE MAKEUP ENDS
001510 *
001512 CONDENSATE:
001514 *
001516 * SUBROUTINE TO INPUT CONDENSATE QUALITY
001518 START12 : ACCEPT                                                   :
001520 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    :
001522 AT(3,5), "**     CONDENSATE RETURN QUALITY OF INTEREST     **",     :
001524 AT(5,2), "ANALYSIS CAN CONTINUE EITHER",                           :
001526 AT(6,3),"THEORETICALLY (BY USING PPM INDICATED AS GOOD QUALITY)",  :
001528 AT(7,10),"OR",                                                     :
001530 AT(8,3), "PRACTICALLY (BY USING ACTUAL CONDENSATE RESULTS)",       :
001532 AT(10,3),"RECOMMEND A RECORD WITH IDEAL SYSTEM CHARACTERISTICS",   :
001534 AT(11,5),"AND A RECORD WITH ACTUAL SYSTEM CHARACTERISTICS TO",      :
001536 AT(12,5),"COMPARE RESULTS AND SEEK ENERGY CONSERVATION AND COST",  :
001538 AT(13,5),"SAVINGS.  CREATE RECORDS BY CHANGING ANY INPUT AND COMP:
001540 ARE THE RESULTS:",                                                 :
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001542 AT(15,2),"ALL SELECTIONS GO INTO DATA RECORDS FOR FUTURE CALCULAT!
001544 IONS",                                                          !
001546 AT(18,1),"PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
001548 ACCEPT                                                          !
001550 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                 !
001552 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
001554 AT(5,5), "**     CONDENSATE RETURN QUALITY OF INTEREST     **",  !
001556 AT(7,3), "A * IN FRONT OF THE ITEM INDICATES IT AS A",          !
001558 AT(8,3), "   REGULAR TEST PERFORMED PER AFP 91-41",             !
001560 AT(9,3), "THE NUMBER IN ( ) IS A GOOD THEORETICAL GUESS FOR",   !
001562 AT(10,3),"   PPM OF THAT ITEM IN GOOD QUALITY CONDENSATE.",     !
001564 AT(12,5),"  TOTAL HARDNESS          (0)(PPM CACO3) ",THCR,      !
001566 PIC(####.##),                                                   !
001568 AT(13,5),"* CALCIUM HARDNESS        (0)(PPM CACO3) ",CACR,      !
001570 PIC(####.##),                                                   !
001572 AT(14,5),"  MAGNESIUM HARDNESS      (0)(PPM CACO3) ",MGCR,      !
001574 PIC(####.##),                                                   !
001576 AT(15,5),"  M ALKALINITY           (15)(PPM CACO3) ",MACR,      !
001578 PIC(####.##),                                                   !
001580 AT(16,5),"* TOTAL DISSOLVED SOLIDS (15)(PPM)       ",TDSCR,     !
001582 PIC(####.##),                                                   !
001584 AT(17,5),"  SILICA                  (0)(PPM SIO2)  ",SICR,      !
001586 PIC(####.##),                                                   !
001588 AT(18,5),"  TOTAL SUSPENDED SOLIDS  (0)(PPM)       ",TSSCR,     !
001590 PIC(####.##),                                                   !
001592 AT(19,5),"* PH                    (7.5)           ",PHCR,      !
001594 PIC(####.##),                                                   !
001596 AT(20,5),"* IRON                   (0)(PPM FE)    ",FECR,      !
001598 PIC(####.##),                                                   !
001600 AT(21,5),"* COPPER                 (0)(PPM CU)    ",CUCR,      !
001602 PIC(####.##), KEYS(BIN(0)) : PRINT
001604 IF PHCR < 4.0 OR PHCR > 10.0 THEN GOTO 1606    ELSE GOTO 1610
001606 PRINT "PH OF CONDENSATE IS OUT OF RANGE" : PRINT : PRINT :      !
001608 GOTO 1548
001610 DEC12 : Y$ = "QQ"
001612 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001614 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT12
001616 IF Y$ = "N" THEN GOTO START12  ELSE GOTO DEC12
001618 EXIT12 : RETURN : REM SUBROUTINE CONDENSATE ENDS
001620 *
001622 FEEDWATER:
001624 *
001626 * SUBROUTINE TO INPUT FEEDWATER QUALITY
001628 START13 : ACCEPT                                                !
001630 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                 !
001632 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
001634 AT(5,5), "**      FEEDWATER QUALITY OF INTEREST      **",       !
001636 AT(7,3), " A * IN FRONT OF THE ITEM INDICATES IT AS A",         !
001638 AT(8,3), "          TEST NEEDED PER AFP 91-41",                 !
001640 AT(10,5),"* CALCIUM HARDNESS       (PPM CACO3) ",CAFT,          !
001642 PIC(####.##),                                                   !
001644 AT(11,5),"* M ALKALINITY           (PPM CACO3) ",MAFT,          !
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001646 PIC(####.##),                                                    !
001648 AT(12,5),"* P ALKALINITY          (PPM CACO3) ",PAFT,            !
001650 PIC(####.##),                                                    !
001652 AT(13,5),"* TOTAL DISSOLVED SOLIDS (PPM)       ",TDSFT,          !
001654 PIC(####.##),                                                    !
001656 AT(14,5),"* SILICA                 (PPM SIO2)  ",SIFT,           !
001658 PIC(####.##), KEYS(BIN(0)) : PRINT
001660 DEC13 : Y$ = "QQ"
001662 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001664 IF Y$ = "E" THEN GOTO EXIT13
001666 IF Y$ = "Y" THEN GOTO 1670
001668 IF Y$ = "N" THEN GOTO START13  ELSE GOTO DEC13
001670 GOSUB MIXING
001672 EXIT13 : RETURN : REM SUBROUTINE FEEDWATER ENDS
001674 *
001676 BOILER:
001678 *
001680 * SUBROUTINE TO INPUT BOILER QUALITY
001682 START14 : ACCEPT                                                 !
001684 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
001686 AT(3,1),  "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",!
001688 AT(5,5),  "**         BOILER QUALITY OF INTEREST       **",     !
001690 AT(7,3),  " A * IN FRONT OF THE ITEM INDICATES IT IS  ",         !
001692 AT(8,3),  "             NEEDED PER AFP 91-41",                   !
001694 AT(10,1), "INPUT VALUES TESTED FROM THE WATER TREATMENT LOG (AF F!
001696 ORM 1459)",                                                      !
001698 AT(12,5), "* HYDROXYL ALKALINITY    (PPM CACO3) ",OHBDT,         !
001700 PIC(####.##),                                                    !
001702 AT(13,5), "* TOTAL DISSOLVED SOLIDS (PPM)       ",TDSBDT,       !
001704 PIC(####.##),                                                    !
001706 AT(14,5), "* PHOSPHATE              (PPM PO4)   ",PHSBDT,       !
001708 PIC(####.##),                                                    !
001710 AT(15,5), "* SULFITE                (PPM SO3)   ",SFBDT,        !
001712 PIC(####.##),                                                    !
001714 AT(16,5), "* LIGNOSULFONATE    (PPM TANNIC ACID)",LSNBDT,        !
001716 PIC(####.##),                                                    !
001718 AT(17,5), "* PH                     (PPM)       ",PHBLR,        !
001720 PIC(####.##), KEYS(BIN(0)) : PRINT
001722 DEC14 : Y$ = "QQ"
001724 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001726 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT14
001728 IF Y$ = "N" THEN GOTO START14  ELSE GOTO DEC14
001730 EXIT14 : RETURN : REM SUBROUTINE BOILER ENDS
001732 *
001734 STEAM:
001736 *
001738 * SUBROUTINE TO INPUT STEAM QUALITY
001740 START15 : ACCEPT                                                 !
001742 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
001744 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
001746 AT(5,5), "   **  STEAM QUALITY OF INTEREST  **",                 !
001748 AT(7,1),"TOTAL DISSOLVED SOLIDS IN STEAM (ASSUME 0 IF PURE) =",  !
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001750 TDSS, PIC(####.##),                                                    !
001752 AT(9,1),"                SILICA IN STEAM (ASSUME 0 IF PURE) =",        !
001754 SIS, PIC(####.##),                                                     !
001756 AT(11,2),"RECOMMEND MEASUREMENT OF STEAM PURITY TWICE A YEAR.",        !
001758 AT(12,4),"TAKE STEAM SAMPLE AT FIRST HIGH PRESSURE DRIP COMING",       !
001760 AT(13,4),"OFF BOILER.  THERE ARE MANY REASONS FOR STEAM NOT TO",       !
001762 AT(14,4),"BE PURE.  ACCEPTED GOOD PRACTICE IS TO HAVE PURE",           !
001764 AT(15,4),"STEAM.  IF TESTING INDICATES POOR STEAM QUALITY,",           !
001766 AT(16,4),"CHECK STEAM SEPARATORS, BOILER WATER LEVEL, OIL IN",         !
001768 AT(17,4),"FEEDWATER, OVERSTEAMING, AND TOTAL DISSOLVED SOLIDS",        !
001770 AT(18,4),"LEVEL IN BOILER.  IF ALL EQUIPMENT AND OPERATION IS",        !
001772 AT(19,4),"PROPER WITHOUT OIL CONTAMINATION OR OTHER REASON FOR",       !
001774 AT(20,4),"FOAMING, REDUCE TOTAL DISSOLVED SOLIDS LEVEL UNTIL",         !
001776 AT(21,4),"STEAM BECOMES PURE.  THIS LAST STATEMENT HOLDS TRUE",        !
001778 AT(22,4),"FOR SILICA ALSO.", KEYS(BIN(0)) : PRINT
001780 DEC15 : Y$ = "QQ"
001782 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001784 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT15
001786 IF Y$ = "N" THEN GOTO START15  ELSE GOTO DEC15
001788 EXIT15 :  RETURN : REM SUBROUTINE STEAM ENDS
001790 *
001792 MIXING:
001794 *
001796* SUBROUTINE TO WARN USER OF P ALKALINITY VERSUS MASSFLOW PROBLEMS
001798 ACCEPT                                                                 !
001800 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                        !
001802 AT(3,2), "MASSFLOW CALCULATIONS INDICATE THAT MOST WATER",              !
001804 AT(4,4), "CONSTITUENTS WILL MIX WELL WHEN THE MAKEUP AND",              !
001806 AT(5,4), "CONDENSATE FLOWS CONVERGE IN THE DEAERATING HEATER.",         !
001808 AT(7,2), "THUS, MOST CONSTITUENT LEVELS CAN BE CALCULATED IN",          !
001810 AT(8,4), "FEEDWATER USING MAKEUP AND CONDENSATE VALUES.",               !
001812 AT(10,2),"USING P ALKALINITY TO COMPUTE FEEDWATER LEVELS IS",           !
001814 AT(11,4),"TOO COMPLEX TO DO BY SIMPLE CALCULATION BASED UPON",          !
001816 AT(12,4),"MASSFLOW.  THE PH, CO2, ALKALINITY RELATIONSHIP",             !
001818 AT(13,4),"CHANGES AS THE FEEDWATER GOES THROUGH THE DEAERATING",        !
001820 AT(14,4),"HEATER.",                                                     !
001822 AT(16,2),"NOTE HOWEVER THAT THE M ALKALINITY RELATIONSHIP TO",          !
001824 AT(17,4),"MASSFLOW DOES SEEM TO HOLD.",                                 !
001826 AT(21,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
001828 RETURN : REM SUBROUTINE MIXING ENDS
001830 *
001832 DISSOLVED:
001834 *
001836 * SUBROUTINE TO SELECT TOTAL DISSOLVED SOLIDS LEVEL IN BLOWDOWN
001838 START16 : ACCEPT                                                       !
001840 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                        !
001842 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",       !
001844 AT(5,5), "                    MAXIMUM TOTAL    SUGGESTED",            !
001846 AT(6,5), " BOILER PRESSURE   DISSOLVED SOLIDS   TARGET",               !
001848 AT(7,5), "      PSIG            (PPM TDS)      (PPM TDS)",            !
001850 AT(9,5), "     0 -  15            6000           5700",               !
001852 AT(10,5),"    16 - 149            4000           3800",               !
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001854 AT(11,5),"   150 - 299            4000            3800",          :
001856 AT(12,5),"   300 - 449            3500            3325",          :
001858 AT(13,5),"   450 - 599            3000            2850",          :
001860 AT(14,5),"   600 - 749            2500            2375",          :
001862 AT(15,5),"   750                  2000            1900",          :
001864 AT(17,2),"TARGET IS BASED ON 95% OF MAXIMUM WITH AN EXPECTED",    :
001866 AT(18,2),"OPERATING RANGE OF 90-100% OF MAXIMUM.",                :
001868 AT(19,5),"NOTE - AFP 91-41 USES MAXIMUM TDS FOR CALCULATIONS",    :
001870 AT(21,1),"SELECTED OPERATING LEVEL FOR TOTAL DISSOLVED SOLIDS (PP:
001872 M) IN BOILER  =",TDSBD, PIC(####.##), KEYS(BIN(0)) : PRINT
001874 IF TDSBD < 1000 OR TDSBD > 6000 THEN GOTO 1876   ELSE GOTO 1880
001876 PRINT "DISSOLVED SOLIDS LEVEL OUT OF RANGE" : PRINT : PRINT :     :
001878 GOTO START16
001880 DEC16 : Y$ = "QQ"
001882 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001884 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT16
001886 IF Y$ = "N" THEN GOTO START16  ELSE GOTO DEC16
001888 EXIT16 : RETURN : REM SUBROUTINE DISSOLVED ENDS
001890 *
001892 SILICA:
001894 *
001896 * SUBROUTINE TO SELECT SILICA LEVEL IN BLOWDOWN
001898 START17 : ACCEPT                                                   :
001900 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   :
001902 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",  :
001904 AT(5,5), "                          MAXIMUM       SUGGESTED",     :
001906 AT(6,5), " BOILER PRESSURE          SILICA         TARGET",       :
001908 AT(7,5), "      PSIG               (PPM SIO2)    (PPM SIO2)",     :
001910 AT(9,5), "     0 -  15               200            190",        :
001912 AT(10,5),"    16 - 149               200            190",        :
001914 AT(11,5),"   150 - 300               150            142",        :
001916 AT(12,5),"   300 - 450                90             85",        :
001918 AT(13,5),"   450 - 599                40             38",        :
001920 AT(14,5),"   600 - 749                30             28",        :
001922 AT(15,5),"   750                      20             19",        :
001924 AT(17,2),"TARGET IS BASED ON 95% OF MAXIMUM WITH AN EXPECTED",    :
001926 AT(18,4),"OPERATING RANGE WITHIN 90-100% OF MAXIMUM.",            :
001928 AT(19,2),"NOTE - AFP 91-41 USES MAXIMUM SIO2 IN ITS CALCULATIONS :
001930 ",                                                                :
001932 AT(21,1),"SELECTED OPERATING LEVEL FOR SILICA (PPM SIO2) IN BOILE:
001934 R  =",SIBD, PIC(####.##), KEYS(BIN(0)) : PRINT
001936 IF SIBD < 10 OR SIBD > 200 THEN GOTO 1938   ELSE GOTO DEC17
001938 PRINT "SILICA LEVEL OUT OF RANGE" : PRINT : PRINT : GOTO START17
001940 DEC17 : Y$ = "QQ"
001942 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
001944 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT17
001946 IF Y$ = "N" THEN GOTO START17  ELSE GOTO DEC17
001948 EXIT17 : RETURN : REM SUBROUTINE SILICA ENDS
001950 *
001952 PHOSPHATE:
001954 *
001956 * SUBROUTINE TO SELECT PHOSPHATE PARAMETERS
```

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001958 START18 : ACCEPT                                                    !
001960 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                     !
001962 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",     !
001964 AT(5,5), "                        RANGE        SUGGESTED",          !
001966 AT(6,5), "BOILER PRESSURE      PHOSPHATE       TARGET",             !
001968 AT(7,5), "     PSIG            (PPM PO4)      (PPM PO4)",          !
001970 AT(9,5), "   0 -  15           NOT USED            0",              !
001972 AT(10,5)," 16 - 750             30 - 60          45",              !
001974 AT(12,2),"TARGET IS BASED ON CENTER OF RANGE.  IF 0-15 PSIG BOILE!
001976 R HAS SOFTENED",                                                    !
001978 AT(13,2),"MAKEUP THEN SUGGEST SAME TARGET AS 16-750 PSIG.",         !
001980 AT(15,1),"SELECTED OPERATING LEVEL FOR PHOSPHATE (PPM PO4) IN BOI!
001982 LER  =",PHSBD, PIC(####.##), KEYS(BIN(0)) : PRINT
001984 IF PBLR <= 15 AND PHSBD > 0 THEN GOTO 1986   ELSE GOTO 1990
001986 PRINT "ONLY USE PHOSPHATE IF MAKEUP IS SOFTENED AND CONDENSATE IS!
001988  PURE." : PRINT : PRINT : PRINT
001990 IF PBLR > 15 AND PHSBD = 0 THEN GOTO 1992   ELSE GOTO 1996
001992 PRINT "PHOSPHATE MAY BE NEEDED TO CONTROL CALCIUM HARDNESS."  :  !
001994 PRINT : PRINT : PRINT
001996 IF PHSBD = 0 THEN GOTO 1998   ELSE GOTO DEC18
001998 PHSPC = .0001 : PHS$ = "NONE USED" : PHSNHD = 0 : PHSNOH = 0
002000 DEC18 : Y$ = "QQ"
002002 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002004 IF Y$ = "E" THEN GOTO EXIT18
002006 IF Y$ = "Y" AND PHSBD > 0 THEN GOTO START19
002008 IF Y$ = "Y" AND PHSBD = 0 THEN GOTO START21
002010 IF Y$ = "N" THEN GOTO START18  ELSE GOTO DEC18
002012 EXIT18 : RETURN : REM EXITING SUBROUTINE
002014 START19 : PHSN = 0
002016 ACCEPT                                                              !
002018 AT(1,1), "                                                  LB CH!
002020 EM    LB NAOH  ",                                                   !
002022 AT(2,1), "                                                 / 1K G!
002024 AL   / 100 LB  ",                                                   !
002026 AT(3,1), "                                          PERCENT  FEEDWT!
002028 R    PHOS CHEM ",                                                  !
002030 AT(4,1), "  CHEMICAL NAME (#)          FORMULA       PO4    / PPM!
002032  HD            ",                                                   !
002034 AT(5,1), "DISODIUM PHOSPHATE,        NA2HPO4*10H2O  26.0     0.02!
002036         11     ",                                                   !
002038 AT(6,1), "  DECAHYDRATE   (1)",                                     !
002040 AT(7,1), "DISODIUM PHOSPHATE,        NA2HPO4        65.7     0.00!
002042 82      28     ",                                                   !
002044 AT(8,1), "  ANHYDROUS     (2)",                                     !
002046 AT(9,1), "TRISODIUM PHOSPHATE,       NA3PO4*12H2O   25.1     0.02!
002048 1        0     ",                                                   !
002050 AT(10,1),"  DODECAHYDRATE (3)",                                     !
002052 AT(11,1),"TRISODIUM PHOSPHATE,       NA3PO4*H2O     52.0     0.01!
002054          0     ",                                                   !
002056 AT(12,1),"  MONOHYDRATE   (4)",                                     !
002058 AT(13,1),"SODIUM TRIPOLYPHOSPHATE,   NA5P3O10*6H2O  61.1     0.00!
002060 88      33.6   ",                                                   !
```

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002062 AT(14,1)," HEXAHYDRATE   (5)",                                          !
002064 AT(15,1),"SODIUM TRIPOLYPHOSPHATE,   NA5P3O10       76.4     0.00!
002066 68      43.5   ",                                                       !
002068 AT(16,1)," ANHYDROUS     (6)",                                          !
002070 AT(17,1),"TETRASODIUM PYROPHOSPHATE  NA4P2O7        71.0     0.00!
002072 72      30.08  ",                                                       !
002074 AT(18,1),"               (7)",                                          !
002076 AT(19,1),"TETRASODIUM PYROPHOSPHATE, NA4P2O7*10H2O  42.7     0.01!
002078 2       17.9   ",                                                       !
002080 AT(20,1)," DECAHYDRATE   (8)",                                          !
002082 AT(21,1),"SODIUM HEXAMETAPHOSPHATE   (NAPO3)6       90.5     0.00!
002084 56      78.4   ",                                                       !
002086 AT(22,1),"               (9)",                                          !
002088 AT(23,1),"NUMBER (#) ABOVE OF CHEMICAL USED OR TYPE <0> FOR YOUR !
002090 INPUT OR REVIEW ",PHSN, PIC(#), KEYS(BIN(0))
002092 IF PHSN = 1 THEN GOTO 2094    ELSE GOTO 2098
002094 PHS$ = "DISODIUM PHOSPHATE DECAHYDRATE"        : PHSPC = 26.0   :!
002096 PHSNHD = 0.02   : PHSNOH = 11    : GOTO START21
002098 IF PHSN = 2 THEN GOTO 2100    ELSE GOTO 2104
002100 PHS$ = "DISODIUM PHOSPHATE ANHYDROUS"          : PHSPC = 65.7   :!
002102 PHSNHD = 0.0082 : PHSNOH = 28    : GOTO START21
002104 IF PHSN = 3 THEN GOTO 2106    ELSE GOTO 2110
002106 PHS$ = "TRISODIUM PHOSPHATE DODECAHYDRATE"     : PHSPC = 25.1   :!
002108 PHSNHD = 0.021  : PHSNOH = 0     : GOTO START21
002110 IF PHSN = 4 THEN GOTO 2112    ELSE GOTO 2116
002112 PHS$ = "TRISODIUM PHOSPHATE MONOHYDRATE"       : PHSPC = 52.0   :!
002114 PHSNHD = 0.01   : PHSNOH = 0     : GOTO START21
002116 IF PHSN = 5 THEN GOTO 2118    ELSE GOTO 2122
002118 PHS$ = "SODIUM TRIPOLYPHOSPHATE HEXAHYDRATE"   : PHSPC = 61.1   :!
002120 PHSNHD = 0.0088 : PHSNOH = 33.6  : GOTO START21
002122 IF PHSN = 6 THEN GOTO 2124    ELSE GOTO 2128
002124 PHS$ = "SODIUM TRIPOLYPHOSPHATE ANHYDROUS"     : PHSPC = 76.4   :!
002126 PHSNHD = 0.0068 : PHSNOH = 43.5  : GOTO START21
002128 IF PHSN = 7 THEN GOTO 2130    ELSE GOTO 2134
002130 PHS$ = "TETRASODIUM PYROPHOSPHATE"             : PHSPC = 71.0   :!
002132 PHSNHD = 0.0072 : PHSNOH = 30.08 : GOTO START21
002134 IF PHSN = 8 THEN GOTO 2136    ELSE GOTO 2140
002136 PHS$ = "TETRASODIUM PYROPHOSPHATE DECAHYDRATE" : PHSPC = 42.7   :!
002138 PHSNHD = 0.012  : PHSNOH = 17.9  : GOTO START21
002140 IF PHSN = 9 THEN GOTO 2142    ELSE GOTO 2146
002142 PHS$ = "SODIUM HEXAMETAPHOSPHATE"              : PHSPC = 90.5   :!
002144 PHSNHD = 0.0056 : PHSNOH = 78.4  : GOTO START21
002146 IF PHSN = 0 THEN GOTO START20  ELSE GOTO START19
002148 START20 : ACCEPT                                                        !
002150 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                         !
002152 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
002154 AT(5,2), "NAME OF PHOSPHATE CHEMICAL USED    ",PHS$, CH(40),     !
002156 AT(7,2), "PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL USED   =", !
002158 PHSPC, PIC(###.####),                                                   !
002160 AT(8,5), "INSERT .0001 IF NO PHOSPHATE IS USED",                        !
002162 AT(10,2),"POUNDS OF PHOSPHATE CHEMICAL REQUIRED TO TREAT 1000 GAL!
002164 LONS OF FEEDWATER PER",                                                 !
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002166 AT(11,4),"PPM HARDNESS  =",PHSNHD, PIC(###.####),                    !
002168 AT(13,2),"POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUN!
002170 DS OF SODIUM",                                                       !
002172 AT(14,2),"HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF PHOSPHATE C!
002174 HEMICAL  =",PHSNOH, PIC(###.####), KEYS(BIN(0)) : PRINT
002176 IF PHSPC <= 0 OR PHSPC > 100 THEN GOTO 2184   ELSE GOTO DEC20
002178 IF PHSNHD <= 0 OR PHSNHD > 0.025 THEN GOTO 2184   ELSE GOTO      !
002180 DEC20
002182 IF PHSNOH < 0 OR PHSNOH > 80 THEN GOTO 2184   ELSE GOTO DEC20
002184 PRINT "VALUE OUT OF RANGE" : PRINT : PRINT : GOTO START20
002186 DEC20 : Y$ = "QQ"
002188 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002190 IF Y$ = "E" THEN GOTO EXIT20
002192 IF Y$ = "Y" THEN GOTO START21
002194 IF Y$ = "N" THEN GOTO START20  ELSE GOTO DEC20
002196 EXIT20 :  RETURN : REM EXITING SUBROUTINE
002198 START21 : ACCEPT                                                     !
002200 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                      !
002202 AT(3,2), "NOTE - THE PHOSPHATE DOSAGE APPLIES TO CALCIUM HARDNESS!
002204 , NOT TOTAL HARDNESS,",                                              !
002206 AT(4,4), "OF THE FEEDWATER.  MAGNESIUM'S PREFERENTIAL REACTION IS!
002208  WITH HYDROXIDE, THEN",                                              !
002210 AT(5,4), "SILICA, AND FINALLY PHOSPHATE.  MAGNESIUM SILICATE (SER!
002212 PENTINE) IS MUCH MORE",                                              !
002214 AT(6,4), "DESIRABLE THAN MAGNESIUM PHOSPHATE IN THE SAME WAY THAT!
002216  CALCIUM PHOSPHATE",                                                 !
002218 AT(7,4), "(HYDROXYAPATITE) IS PREFERRED OVER CALCIUM SULFATE.  IN!
002220  EACH CASE, THE",                                                    !
002222 AT(8,4), "PREFERRED COMPOUND IS EASILY HANDLED WITH THE STANDARD  !
002224 SLUDGE CONDITIONER.",                                                !
002226 AT(10,2),"NOTE - AFP 91-41 ASSUMES 8.33 LBS/GALLON OF WATER TO DE!
002228 TERMINE THE GALLONS",                                                !
002230 AT(11,4),"OF FEEDWATER AND CALCULATE THE PHOSPHATE NEEDED TO REAC!
002232 T WITH HARDNESS.",                                                   !
002234 AT(12,4),"PRESSURE AND TEMPERATURE AFFECT THIS VALUE AND THIS AFF!
002236 ECTS THE ACTUAL",                                                    !
002238 AT(13,4),"GALLONS THAT WILL BE MEASURED BY A WATER METER.  THIS I!
002240 S WHY CALCULATIONS",                                                 !
002242 AT(14,4),"ARE DONE IN POUNDS/HOUR AS IT IS NOT VOLUME DEPENDENT!  !
002244 ",                                                                   !
002246 AT(18,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
002248 START22 : ACCEPT                                                     !
002250 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                      !
002252 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",  !
002254 AT(5,5), "*  FEEDWATER (DEAERATING HEATER EFFLUENT)  *",           !
002256 AT(7,5), "     TEMPERATURE  PRESSURE      DENSITY   ",             !
002258 AT(8,5), "       (DEG F)     (PSIG)   (POUNDS/GALLON)",            !
002260 AT(10,5),"        32        0 / 500    8.344 / 8.358",            !
002262 AT(11,5),"        50        0 / 500    8.343 / 8.356",            !
002264 AT(12,5),"        54.5       UNK           8.341    ",            !
002266 AT(13,5),"        68         UNK           8.331    ",            !
002268 AT(14,5),"           AFP 91-41             8.33     ",            !
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002270 AT(15,5),"       100         0 / 500    8.288 / 8.300",          !
002272 AT(16,5),"       150         0 / 500    8.180 / 8.192",          !
002274 AT(17,5),"       200         0 / 500    8.036 / 8.049",          !
002276 AT(18,5),"       250         0 / 500    7.862 / 7.877",          !
002278 AT(20,1),"SELECTED FEEDWATER POUNDS/GALLON FOR CALCULATIONS   =",!
002280 DENSF, PIC(###.####), KEYS(BIN(0)) : PRINT
002282 IF DENSF <= 7 OR DENSF >= 8.5 THEN GOTO 2284    ELSE GOTO 2288
002284 PRINT "DENSITY OF FEEDWATER OUT OF RANGE" :                      !
002286 PRINT : PRINT : GOTO START22
002288 DEC22 : Y$ = "QQ"
002290 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002292 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT22
002294 IF Y$ = "N" THEN GOTO START22  ELSE GOTO DEC22
002296 EXIT22 : RETURN : REM SUBROUTINE PHOSPHATE ENDS
002298 *
002300 HYDROXYL:
002302 *
002304 * SUBROUTINE TO SELECT HYDROXYL ALKALINITY LEVEL IN BOILER
002306 START23 : ACCEPT                                                  !
002308 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
002310 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
002312 AT(5,5), "                          RANGE        SUGGESTED",     !
002314 AT(6,5), " BOILER PRESSURE    OH ALKALINITY    OH TARGET",       !
002316 AT(7,5), "      PSIG           (PPM CACO3)    (PPM CACO3)",     !
002318 AT(9,5), "     0 -  15          300 - 550         360",          !
002320 AT(10,5),"    16 - 149          220 - 500         265",          !
002322 AT(11,5),"   150 - 299          220 - 500         265",          !
002324 AT(12,5),"   300 - 449          180 - 450         215",          !
002326 AT(13,5),"   450 - 599          170 - 425         205",          !
002328 AT(14,5),"   600 - 749          170 - 550         205",          !
002330 AT(15,5),"   750                170 - 425         205",          !
002332 AT(17,2),"TARGET IS BASED ON 120% OF MINIMUM.",                  !
002334 AT(19,1),"SELECTED OPERATING LEVEL FOR HYDROXYL ALKALINITY (PPM C!
002336 ACO3)",                                                          !
002338 AT(20,1),"IN BOILER  =",OHBD, PIC(####.##),                      !
002340 AT(22,1),"PURITY (%) OF CAUSTIC SODA USED (DRY USUALLY 98)  =",  !
002342 NAOHPC, PIC(####.##), KEYS(BIN(0)) : PRINT
002344 IF OHBD < 170 OR OHBD > 550 OR  NAOHPC <= 0 OR NAOHPC > 100 THEN !
002346 GOTO 2348   ELSE GOTO 2352
002348 PRINT "HYDROXYL LEVEL OR CAUSTIC SODA PURITY OUT OF RANGE" :     !
002350 PRINT : PRINT: GOTO START23
002352 DEC23 : Y$ = "QQ"
002354 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002356 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT23
002358 IF Y$ = "N" THEN GOTO START23  ELSE GOTO DEC23
002360 EXIT23 : RETURN : REM SUBROUTINE HYDROXYL ENDS
002362 *
002364 BREAKDOWN:
002366 *
002368 * SUBROUTINE TO SELECT % CARBONATE ALKALINITY BREAKDOWN IN BOILER
002370 START24 : ACCEPT                                                  !
002372 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
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002374 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
002376 AT(5,5), "                    CARBONATE   ",                      !
002378 AT(6,5), " BOILER PRESSURE   ALKALINITY  ",                      !
002380 AT(7,5), "      PSIG         % BREAKDOWN ",                      !
002382 AT(9,5), "       200           70 - 90   ",                      !
002384 AT(10,5),"      >150             80+     ",                      !
002386 AT(11,5),"    50 - 150         30 - 80   ",                      !
002388 AT(12,5),"       100           20 - 40   ",                      !
002390 AT(13,5),"    10 -  50         10 - 30   ",                      !
002392 AT(15,1),"SELECTED % OF CARBONATE ALKALINITY BREAKDOWN IN BOILER !
002394  =",CARBPC, PIC(####.##), KEYS(BIN(0)) : PRINT
002396 IF CARBPC <= 0 OR CARBPC > 100 THEN GOTO 2398   ELSE GOTO 2402
002398 PRINT "% CARBONATE ALKALINITY BREAKDOWN OUT OF RANGE" :           !
002400 PRINT : PRINT : GOTO 2370
002402 DEC24 : Y$ = "QQ"
002404 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002406 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT24
002408 IF Y$ = "N" THEN GOTO START24  ELSE GOTO DEC24
002410 EXIT24 : RETURN : REM SUBROUTINE BREAKDOWN ENDS
002412 *
002414 LIGNOSULFONATE:
002416 *
002418 * SUBROUTINE TO SELECT LIGNOSULFONATE LEVEL IN BOILER BLOWDOWN
002420 START25 : ACCEPT                                                  !
002422 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
002424 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
002426 AT(5,5), "                        RANGE            SUGGESTED  ", !
002428 AT(6,5), "BOILER PRESSURE   LIGNOSULFONATE          TARGET    ", !
002430 AT(7,5), "     PSIG        (PPM TANNIC ACID)  (PPM TANNIC ACID)",!
002432 AT(9,5), "    0 -  15          70 - 100              85  ",      !
002434 AT(10,5),"   16 - 149          70 - 100              85  ",      !
002436 AT(11,5),"  150 - 299          70 - 100              85  ",      !
002438 AT(12,5),"  300 - 449          70 - 100              85  ",      !
002440 AT(13,5),"  450 - 599          60 -  90              75  ",      !
002442 AT(14,5),"  600 - 749          50 -  80              65  ",      !
002444 AT(15,5),"  750                40 -  70              55  ",      !
002446 AT(17,1),"SELECTED LIGNOSULFONATE OPERATING LEVEL IN BOILER (PPM !
002448 TANNIC ACID) =",LSNBD, PIC(####.##),                              !
002450 AT(19,1),"PURITY (%) OF LIGNOSULFONATE CHEMICAL USED BASED ON TAN!
002452 NIC ACID CONTENT",                                               !
002454 AT(20,1),"(ASSUME 100 UNLESS MANUFACTURER OR ACTUAL TEST INDICATE!
002456 S OTHERWISE)  =",LSNPC, PIC(####.##), KEYS(BIN(0)) : PRINT
002458 IF LSNPC <= 0 OR LSNPC > 100 OR LSNBD < 40 OR LSNBD > 100 THEN   !
002460 GOTO 2462   ELSE GOTO DEC25
002462 PRINT "LIGNOSULFONATE LEVEL OR CHEMICAL PURITY OUT OF RANGE" :   !
002464 PRINT : PRINT : GOTO START25
002466 DEC25 : Y$ = "QQ"
002468 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002470 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT25
002472 IF Y$ = "N" THEN GOTO START25  ELSE GOTO DEC25
002474 EXIT25 : RETURN : REM SUBROUTINE LIGNOSULFONATE ENDS
002476 *
```

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002478 SULFITE:
002480 *
002482 * SUBROUTINE TO SELECT SULFITE LEVEL IN BLOWDOWN
002484 START26 : ACCEPT                                                    !
002486 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    !
002488 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",    !
002490 AT(5,5), "                      RANGE     SUGGESTED ",             !
002492 AT(6,5), "BOILER PRESSURE    SULFITE     TARGET   ",               !
002494 AT(7,5), "     PSIG         (PPM SO3)   (PPM SO3) ",               !
002496 AT(9,5), "    0 -  15        30 - 60       45     ",               !
002498 AT(10,5),"   16 - 149        30 - 60       45     ",               !
002500 AT(11,5),"  150 - 299        30 - 60       45     ",               !
002502 AT(12,5),"  300 - 449        20 - 40       30     ",               !
002504 AT(13,5),"  450 - 599        20 - 40       30     ",               !
002506 AT(14,5),"  600 - 749        15 - 30       23     ",               !
002508 AT(15,5),"  750              NOT RECOMMENDED      ",               !
002510 AT(17,1),"SELECTED SULFITE (PPM SO3) OPERATING LEVEL IN BOILER  =!
002512 ",SFBD, PIC(####.##),                                              !
002514 AT(19,1), "PURITY (%) OF SULFITE CHEMICAL USED (USUALLY 90)  =", !
002516 SFPC, PIC(####.##), KEYS(BIN(0)) : PRINT
002518 IF SFPC <= 0 OR SFPC > 100 OR SFBD > 60 THEN GOTO 2522   ELSE    !
002520 GOTO 2526
002522 PRINT "SULFITE LEVEL OR CHEMICAL PURITY OUT OF RANGE" :           !
002524 PRINT : PRINT : GOTO START26
002526 DEC26 : Y$ = "QQ"
002528 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002530 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT26
002532 IF Y$ = "N" THEN GOTO START26  ELSE GOTO DEC26
002534 EXIT26 : RETURN : REM SUBROUTINE SULFITE ENDS
002536 *
002538 AMINE:
002540 *
002542 * SUBROUTINE TO SELECT AMINE LEVELS BASED ON FEEDWATER ALKALINITY
002544 START27 : ACCEPT                                                   !
002546 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
002548 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",   !
002550 AT(5,2), "NEUTRALIZING AMINE DOSAGES ARE DIFFICULT TO CALCULATE D!
002552 UE TO MANY VARIABLES.",                                            !
002554 AT(6,4), "FEEDWATER ALKALINITY IS IMPORTANT TO THE DETERMINATION  !
002556 OF AMINE DOSAGES.",                                                !
002558 AT(8,2), "AFP 91-41 SEEKS A 50/50 MIXTURE OF CYCLOHEXYLAMINE AND  !
002560 MORPHOLINE INITIALLY.",                                            !
002562 AT(9,4), "GOAL IS TO ACHIEVE FINAL OPERATION AT PH 7.5 TO 8.0 THR!
002564 OUGHOUT THE",                                                      !
002566 AT(10,4),"CONDENSATE SYSTEM.",                                     !
002568 AT(12,2),"USE FREQUENT TESTS AND ADJUSTMENTS INITIALLY.",          !
002570 AT(13,2),"THEN TEST THE CONDENSATE SYSTEM THOROUGHLY TWICE YEARLY!
002572  THEREAFTER.",                                                     !
002574 AT(15,1),"PURITY (%) OF CYCLOHEXYLAMINE USED (60 OR 98) =",CHAPC,!
002576 PIC(####.##),                                                      !
002578 AT(16,1),"PURITY (%) OF MORPHOLINE USED (40, 91, OR 99) =",MORPC,!
002580 PIC(####.##),                                                      !
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002582 KEYS(BIN(0)) : PRINT
002584 IF CHAPC <= 0 OR CHAPC > 100 OR MORPC <= 0 OR MORPC > 100 THEN   !
002586 GOTO 2588   ELSE GOTO DEC27
002588 PRINT "PURITY OF NEUTRALIZING AMINES OUT OF RANGE" :             !
002590 PRINT : PRINT : GOTO START27
002592 DEC27 : Y$ = "QQ"
002594 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002596 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT27
002598 IF Y$ = "N" THEN GOTO START27  ELSE GOTO DEC27
002600 EXIT27 : RETURN : REM SUBROUTINE AMINE ENDS
002602 *
002604 DISTRIBUTION:
002606 *
002608 * SUBROUTINE TO SELECT DISTRIBUTION RATIO OF AMINES
002610 START28 : ACCEPT                                                  !
002612 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
002614 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
002616 AT(5,2), "DISTRIBUTION RATIO IS A MEASURE OF THE RELATIONSHIP BET!
002618 WEEN THE AMINE IN",                                              !
002620 AT(6,2), "VAPOR PHASE AND THE AMINE IN LIQUID PHASE.  THE HIGHER !
002622 THE RATIO THE MORE",                                             !
002624 AT(7,2), "EASILY THE AMINE EVAPORATES AND STAYS IN VAPOR PHASE.",!
002626 AT(9,5), "BOILER PRESSURE        DISTRIBUTION RATIO       ",     !
002628 AT(10,5),"     PSIG          CYCLOHEXYLAMINE   MORPHOLINE  ",     !
002630 AT(12,5),"       0                 4.0             0.40     ",     !
002632 AT(13,5),"     150                 9.0             0.85     ",     !
002634 AT(14,5),"     450                 9.4             1.33     ",     !
002636 AT(15,5),"     600                 8.2             1.02     ",     !
002638 AT(17,1),"SELECTED DISTRIBUTION RATIO FOR CYCLOHEXYLAMINE  =",    !
002640 CHADR, PIC(####.##),                                             !
002642 AT(18,1),"SELECTED DISTRIBUTION RATIO FOR MORPHOLINE       =",    !
002644 MORDR, PIC(####.##), KEYS(BIN(0)) : PRINT
002646 IF CHADR < 4 OR CHADR > 10 OR MORDR < 0.4 OR MORDR > 1.5 THEN    !
002648 GOTO 2650   ELSE GOTO DEC28
002650 PRINT "DISTRIBUTION RATIOS OUT OF RANGE" :                       !
002652 PRINT : PRINT : GO TO START28
002654 DEC28 : Y$ = "QQ"
002656 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002658 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT28
002660 IF Y$ = "N" THEN GOTO START28  ELSE GOTO DEC28
002662 EXIT28 : RETURN : REM SUBROUTINE DISTRIBUTION ENDS
002664 *
002666 DOSAGE:
002668 *
002670 * SUBROUTINE TO INPUT CHEMICAL DOSAGES FOR ANALYSIS COMPARISON
002672 START29 : ACCEPT                                                  !
002674 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
002676 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE", !
002678 AT(5,2), "**                CHEMICAL DOSAGES                **",   !
002680 AT(6,2), "**          AVERAGE DOSAGES - POUNDS/DAY          **",   !
002682 AT(7,2), "**     FOR THE STEAM PRODUCTION OF INTEREST       **",   !
002684 AT(8,2), "**  TAKEN FROM THE BOILER WATER TREATMENT LOGS    **",   !
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002686 AT(10,1),"INSERT DOSAGE OPPOSITE CHEMICAL NAME LISTED.  IF SUBSTI!
002688 TUTE USED, INSERT NAME",                                          !
002690 AT(11,1),"  AND DOSAGE UNDERNEATH CHEMICAL WITH SAME FUNCTION.", !
002692 AT(13,5),"CAUSTIC SODA (NAOH)                        ",LBOH,      !
002694 PIC(###.##),                                                      !
002696 AT(14,5),OTHOH$, CH(40), LBOTHOH, PIC(###.##),                    !
002698 AT(15,5),"PHOSPHATE CHEMICAL LISTED IN AFP 91-41  ",LBPHS,        !
002700 PIC(###.##),                                                      !
002702 AT(16,5),OTHPHS$, CH(40), LBOTHPHS, PIC(###.##),                  !
002704 AT(17,5),"SODIUM SULFITE (NA2SO3)                    ",LBSF,      !
002706 PIC(###.##),                                                      !
002708 AT(18,5),OTHSF$, CH(40), LBOTHSF, PIC(###.##),                    !
002710 AT(19,5),"LIGNOSULFONATE                             ",LBLSN,     !
002712 PIC(###.##),                                                      !
002714 AT(20,5),OTHLSN$, CH(40), LBOTHLSN, PIC(###.##),                  !
002716 AT(21,5),"CYCLOHEXYLAMINE                            ",LBCHA,     !
002718 PIC(###.##),                                                      !
002720 AT(22,5),"MORPHOLINE                                 ",LBMOR,     !
002722 PIC(###.##),                                                      !
002724 AT(23,5),OTHAM$, CH(40), LBOTHAM, PIC(###.##),                    !
002726 KEYS(BIN(0)) : PRINT
002728 DEC29 : Y$ = "QQ"
002730 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
002732 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT29
002734 IF Y$ = "N" THEN GOTO START29  ELSE GOTO DEC29
002736 EXIT29 : RETURN : REM SUBROUTINE DOSAGE ENDS
002738 *
002740 INPUT3:
002742 *
002744 * BEGIN SUBROUTINE TO EDIT EXISTING DATA RECORD
002746 N = 1
002748 ACCEPT                                                            !
002750 AT(2,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
002752 AT(4,1), "INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAM!
002754 E (KEYFIELD) OF THE DATA",                                        !
002756 AT(5,3), "RECORD YOU ARE INTERESTED IN.  YOU WILL THEN HAVE TO ST!
002758 EP THROUGH THE RECORDS",                                          !
002760 AT(6,3), "UNTIL YOU FIND THE ONE YOU WANT.",                       !
002762 AT(9,10),"COMPUTER USER ID  = ",UID$,CH(3),                        !
002764 AT(13,1),  "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
002766 OPEN NODISPLAY #1, SHARED,FILE="ESTM",LIBRARY="EIXXDATA",          !
002768 VOLUME=DEEDATAVOL$,SPACE=100
002770 IF N = 1 THEN GOTO 2772   ELSE GOTO 2774
002772 READ #1, HOLD, KEY = UID$, EOD GOTO EXIT30 : GOTO 2776
002774 START30 : READ #1, HOLD, EOD GOTO EXIT30
002776 N = N + 1
002778 GET #1 USING LYT1 , UID$,DATE$,BASEID$,BLDG$,BLR$,RID$,           !
002780 AMSL,BASE$,                                                       !
002782 CACR,CAMU,CARBPC,CHAPC,                                           !
002784 LSNBD,LSNPC,                                                      !
002786 MACR,MAFT,MAMU,MGCR,MGMU,MORPC,                                   !
002788 NAOHPC,OHBDT,OPR$,OXF,                                            !
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002790 PAFT,PBLR,PDA,PHBLR,PHSBD,PHSPC,PHSNHD,PHSNOH,PHS$,                    !
002792 QL,QS,RS,SIBD,SICR,SIFT,SIMU,SIS,SFBD,SFPC,                           !
002794 TDSBD,TDSCR,TDSFT,TDSMU,TDSS,TF,TSSCR,TSSMU,                          !
002796 CUCR,FECR,PHCR,THCR,THMU,DENSF,                                       !
002798 V0$,V1$,V2$,V3$,V4$,V5$,V6$,V7$,                                      !
002800 CAFT,CHADR,MORDR,OHBD,                                                !
002802 LSNBDT,PHSBDT,SFBDT,TDSBDT,                                           !
002804 LBCHA,LBLSN,LBMOR,LBOH,LBPHS,LBSF,                                    !
002806 LBOTHAM,LBOTHLSN,LBOTHOH,LBOTHPHS,LBOTHSF,                            !
002808 OTHAM$,OTHLSN$,OTHOH$,OTHPHS$,OTHSF$,COMMENT$
002810 START30A : Y$ = "QQ"
002812 ACCEPT                                                                !
002814 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                       !
002816 AT(3,1), "THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE       !
002818 DATA RECORD OBSERVED.",                                               !
002820 AT(5,1), "SELECT ACTION FOR RECORD OF INTEREST LISTED AT BOTTOM O      !
002822 F SCREEN.",                                                           !
002824 AT(6,5), "INPUT ACTION SELECTION",FAC(HEX(91)),Y$,CH(1),               !
002826 AT(7,2), "(S) = SELECT THIS RECORD TO REVIEW AND/OR EDIT",             !
002828 AT(8,2), "(N) = GO TO NEXT RECORD",                                    !
002830 AT(9,2), "(R) = RETAIN EXISTING RECORD NAME AFTER REVIEW/EDIT, TH      !
002832 EN EXIT",                                                             !
002834 AT(10,2), "(C) = RENAME RECORD ABOVE AFTER EDIT AND CREATE NEW RE      !
002836 CORD, THEN EXIT",                                                     !
002838 AT(11,2), "(E) = EXIT TO PREVIOUS MENU WITH NO ACTION TAKEN",         !
002840 AT(13,5), "MODIFY ENTRIES BELOW ONLY AFTER EDIT FOR OPTION (C) AB      !
002842 OVE!",                                                                !
002844 AT(14,9), "COMPUTER USER ID     ",FAC(HEX(89)),UID$,CH(3),            !
002846 AT(15,9), "TODAY'S DATE         ",FAC(HEX(89)),DATE$,CH(6),           !
002848 AT(16,9), "BASE ID              ",FAC(HEX(89)),BASEID$,CH(3),         !
002850 AT(17,9), "BUILDING NUMBER      ",FAC(HEX(89)),BLDG$,CH(7),           !
002852 AT(18,9), "BOILER DESIGNATOR    ",FAC(HEX(89)),BLR$,CH(2),            !
002854 AT(19,9), "RUN INDICATOR        ",FAC(HEX(89)),RID$,CH(2),            !
002856 AT(20,1), "COMMENT DESCRIBING THIS DATA ",FAC(HEX(89)),COMMENT$,       !
002858 CH(45),                                                               !
002860 AT(22,5), "IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE      !
002862  USER ID REQUEST.",                                                   !
002864 AT(24,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
002866 IF Y$ = "E" THEN GOTO EXIT30
002868 IF Y$ = "R" OR Y$ = "C" THEN GOTO NEXT30
002870 IF Y$ = "N" THEN GOTO START30
002872 IF Y$ = "S" THEN GOTO START31  ELSE GOTO START30A
002874 NEXT30 : PUT #1 USING LYT1 , UID$,DATE$,BASEID$,BLDG$,BLR$,RID$,      !
002876 AMSL,BASE$,                                                           !
002878 CACR,CAMU,CARBPC,CHAPC,                                               !
002880 LSNBD,LSNPC,                                                          !
002882 MACR,MAFT,MAMU,MGCR,MGMU,MORPC,                                       !
002884 NAOHPC,OHBDT,OPR$,OXF,                                                !
002886 PAFT,PBLR,PDA,PHBLR,PHSBD,PHSPC,PHSNHD,PHSNOH,PHS$,                   !
002888 QL,QS,RS,SIBD,SICR,SIFT,SIMU,SIS,SFBD,SFPC,                           !
002890 TDSBD,TDSCR,TDSFT,TDSMU,TDSS,TF,TSSCR,TSSMU,                          !
002892 CUCR,FECR,PHCR,THCR,THMU,DENSF,                                       !
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002894 V0$,V1$,V2$,V3$,V4$,V5$,V6$,V7$,                                    :
002896 CAFT,CHADR,MORDR,OHBD,                                              :
002898 LSNBDT,PHSBDT,SFBDT,TDSBDT,                                         :
002900 LBCHA,LBLSN,LBMOR,LBOH,LBPHS,LBSF,                                  :
002902 LBOTHAM,LBOTHLSN,LBOTHOH,LBOTHPHS,LBOTHSF,                          :
002904 OTHAM$,OTHLSN$,OTHOH$,OTHPHS$,OTHSF$,COMMENT$
002906 IF Y$ = "C" THEN GOTO EXIT30A
002908 IF Y$ = "R" THEN GOTO 2910
002910 REWRITE #1
002912 EXIT30 : CLOSE #1 : RETURN : REM SUBROUTINE INPUT3 ENDS
002914 EXIT30A: WRITE #1 : CLOSE #1 : RETURN : REM SUBROUTINE INPUT3 ENDS
002916 START31 : Z = 0
002918 ACCEPT                                                              :
002920 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                     :
002922 AT(3,1), "SELECT INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",        :
002924 AT(5,5), "ENTER FOR ACTION          ENTER FOR ACTION            ",:
002926 AT(6,5), "-----  ----------         -----  ----------           ",:
002928 AT(7,5), "  1   ACCESS IDENTIFIED RECORD                        ",:
002930 AT(9,5), "REVIEW SELECTION CRITERIA FOR THE FOLLOWING           ",:
002932 AT(10,5),"  3   SYSTEM OPERATIONS     23  SILICA                ",:
002934 AT(11,5),"  4   ALTITUDE OF BOILER    24  PHOSPHATE             ",:
002936 AT(12,5),"  5   DEAERATOR OPERATION   25  HYDROXYL ALKALINITY   ",:
002938 AT(13,5),"  6   PRETREATMENT          26  ALKALINITY BREAKDOWN  ",:
002940 AT(14,5),"  7   MAKEUP QUALITY        27  LIGNO SULFONATE       ",:
002942 AT(15,5),"  8   CONDENSATE QUALITY    28  SULFITE               ",:
002944 AT(16,5),"  9   FEEDWATER QUALITY     29  NEUTRALIZING AMINE    ",:
002946 AT(17,5)," 10   BOILER QUALITY        30  AMINE DISTRIBUTION    ",:
002948 AT(18,5)," 11   STEAM QUALITY         31  RECORDED DOSAGES      ",:
002950 AT(19,5)," 12   TOT DISSOLVED SOLIDS                           ",:
002952 AT(20,5),"   16      RETURN TO PREVIOUS MENU",                      :
002954 AT(22,10), "ACTION NUMBER",FAC(HEX(91)), Z, PIC(##), KEYS(BIN(0))
002956 IF Z = 16 THEN GOTO EXIT31
002958 IF Z = 1 THEN GOSUB EDIT1
002960 IF Z = 3 THEN GOSUB OPERATIONS
002962 IF Z = 4 THEN GOSUB ALTITUDE
002964 IF Z = 5 THEN GOSUB DEAERATOR
002966 IF Z = 6 THEN GOSUB PRETREATMENT
002968 IF Z = 7 THEN GOSUB MAKEUP
002970 IF Z = 8 THEN GOSUB CONDENSATE
002972 IF Z = 9 THEN GOSUB FEEDWATER
002974 IF Z = 10 THEN GOSUB BOILER
002976 IF Z = 11 THEN GOSUB STEAM
002978 IF Z = 12 THEN GOSUB DISSOLVED
002980 IF Z = 23 THEN GOSUB SILICA
002982 IF Z = 24 THEN GOSUB PHOSPHATE
002984 IF Z = 25 THEN GOSUB HYDROXYL
002986 IF Z = 26 THEN GOSUB BREAKDOWN
002988 IF Z = 27 THEN GOSUB LIGNOSULFONATE
002990 IF Z = 28 THEN GOSUB SULFITE
002992 IF Z = 29 THEN GOSUB AMINE
002994 IF Z = 30 THEN GOSUB DISTRIBUTION
002996 IF Z = 31 THEN GOSUB DOSAGE
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002998 GOTO START31 : REM ONLY WAY TO EXIT IS THROUGH Z = 16 ON MENU
003000 EXIT31 : GOTO START30A
003002 *
003004 EDIT1:
003006 *
003008 * SUBROUTINE TO EDIT EXISTING DATA RECORD
003010 START32 : ACCEPT                                                    !
003012 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    !
003014 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",       !
003016 AT(5,5), "INSTALLATION                          ",BASE$, CH(20),   !
003018 AT(6,5), "BUILDING NUMBER                       ",BLDG$, CH(7),    !
003020 AT(7,5), "BOILER DESIGNATION                    ",BLR$, CH(2),     !
003022 AT(8,5), "LAST NAME OF PERSON WHO MADE RECORD ",OPR$, CH(15),       !
003024 AT(9,1), "COMMENT DESCRIBING THIS DATA  ",COMMENT$,CH(45),          !
003026 AT(11,15),"**     STEAM PRODUCTION DATA     **",                   !
003028 AT(13,1),"OPERATING GAUGE PRESSURE OF BOILER = ",PBLR,              !
003030 PIC(####.##),                                                       !
003032 AT(15,1),"RATED STEAM PRODUCTION (POUNDS/HOUR) OF BOILER           !
003034  =",RS, PIC(########.##),                                          !
003036 AT(16,1),"ACTUAL STEAM PRODUCTION INVESTIGATED (POUNDS/HOUR QS)    !
003038  =",QS, PIC(########.##),                                          !
003040 AT(18,1),"ESTIMATED LOSSES STEAM AND CONDENSATE (POUNDS/HOUR QL)   !
003042  =",QL, PIC(########.##),                                          !
003044 AT(20,1),"ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL (FT) =",AMSL,     !
003046 PIC(######),                                                       !
003048 AT(22,1),"**    NOTE - IF EXITING, ALL DATA ENTERED TO THAT POINT!
003050  WILL BE SAVED!    **", KEYS(BIN(0)) : PRINT
003052 IF PBLR <= 0 OR QS <= 0 THEN GOTO 3054   ELSE GOTO DEC32
003054 PRINT "VALUES OUT OF RANGE" : PRINT : PRINT : GOTO START32
003056 DEC32 : Y$ = "QQ"
003058 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003060 IF Y$ = "E" THEN GOTO EXIT32
003062 IF Y$ = "Y" THEN GOTO START33
003064 IF Y$ = "N" THEN GOTO START32  ELSE GOTO DEC32
003066 EXIT32 : RETURN : REM SUBROUTINE EDIT1 ENDS
003068 START33 : ACCEPT                                                   !
003070 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                    !
003072 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",       !
003074 AT(5,15),"**     DFAERATING HEATER DATA     **",                   !
003076 AT(7,1),"OPERATING TEMPERATURE OF DEAERATING HEATER (DEG F)  =",    !
003078 TF, PIC(####.##),                                                  !
003080 AT(8,1),"OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG)=",    !
003082 PDA, PIC(####.##),                                                 !
003084 AT(9,1),"OXYGEN (PPM O2) IN 'DEAERATING HEATER' EFFLUENT     = ",!
003086 OXF, PIC(###.####),                                                !
003088 AT(12,10), "'Y' INDICATES APPLICABLE PRETREATMENT ",                !
003090 AT(14,5),"FILTER                              ",V0$, CH(1),        !
003092 AT(15,5),"SODIUM ZEOLITE SOFTENER             ",V1$, CH(1),        !
003094 AT(16,5),"HYDROGEN ZEOLITE SOFTENER           ",V2$, CH(1),        !
003096 AT(17,5),"SPLIT STREAM SOFTENING              ",V3$, CH(1),        !
003098 AT(18,5),"ZEOLITE DEALKALIZER                 ",V4$, CH(1),        !
003100 AT(19,5),"COLD LIME-SODA SOFTENER             ",V5$, CH(1),        !
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003102 AT(20,5),"HOT LIME-SODA SOFTENER          ",V6$, CH(1),          !
003104 AT(21,5),"DEGASIFIER                      ",V7$, CH(1),          !
003106 KEYS(BIN(0)) : PRINT
003108 IF TF < 0 OR TF > 260 THEN GOTO 3114   ELSE GOTO 3110
003110 IF PDA < 0 OR PDA > 25 THEN GOTO 3114   ELSE GOTO 3112
003112 IF OXF < 0.007 OR OXF > 10 THEN GOTO 3114   ELSE GOTO DEC33
003114 PRINT "VALUES OUT OF RANGE" : PRINT : PRINT : GOTO START33
003116 DEC33 : Y$ = "QQ"
003118 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003120 IF Y$ = "E" THEN GOTO EXIT33
003122 IF Y$ = "Y" THEN GOTO START34
003124 IF Y$ = "N" THEN GOTO START33  ELSE GOTO DEC33
003126 EXIT33 : RETURN : REM SUBROUTINE EDIT1 ENDS
003128 START34 : ACCEPT                                                  !
003130 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
003132 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",      !
003134 AT(5,2), "**     MAKEUP WATER QUALITY OF INTEREST     **",        !
003136 AT(6,2), "**          AFTER ALL PRETREATMENT          **",        !
003138 AT(8,3), " A * IN FRONT OF THE ITEM INDICATES IT AS A",            !
003140 AT(9,3), "   REGULAR TEST PERFORMED PER AFP 91-41",                !
003142 AT(11,5),"  TOTAL HARDNESS          (PPM CACO3) ",THMU,            !
003144 PIC(####.##),                                                      !
003146 AT(12,5),"* CALCIUM HARDNESS        (PPM CACO3) ",CAMU,            !
003148 PIC(####.##),                                                      !
003150 AT(13,5),"  MAGNESIUM HARDNESS      (PPM CACO3) ",MGMU,            !
003152 PIC(####.##),                                                      !
003154 AT(14,5),"* M ALKALINITY            (PPM CACO3) ",MAMU,            !
003156 PIC(####.##),                                                      !
003158 AT(15,5),"* TOTAL DISSOLVED SOLIDS (PPM)        ",TDSMU,           !
003160 PIC(####.##),                                                      !
003162 AT(16,5),"  SILICA                  (PPM SIO2)  ",SIMU,            !
003164 PIC(####.##),                                                      !
003166 AT(17,5),"  TOTAL SUSPENDED SOLIDS (PPM)        ",TSSMU,           !
003168 PIC(####.##), KEYS(BIN(0)) : PRINT
003170 DEC34 : Y$ = "QQ"
003172 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003174 IF Y$ = "E" THEN GOTO EXIT34
003176 IF Y$ = "Y" THEN GOTO START35
003178 IF Y$ = "N" THEN GOTO START34  ELSE GOTO DEC34
003180 EXIT34 : RETURN : REM SUBROUTINE EDIT1 ENDS
003182 START35 : ACCEPT                                                  !
003184 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
003186 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",      !
003188 AT(5,5), "**     CONDENSATE RETURN QUALITY OF INTEREST     **",    !
003190 AT(7,3), "A * IN FRONT OF THE ITEM INDICATES IT AS A",             !
003192 AT(8,3), "   REGULAR TEST PERFORMED PER AFP 91-41",                !
003194 AT(9,3), "THE NUMBER IN ( ) IS A GOOD THEORETICAL GUESS FOR",      !
003196 AT(10,3),"   PPM OF THAT ITEM IN GOOD QUALITY CONDENSATE.",        !
003198 AT(12,5),"  TOTAL HARDNESS          (0)(PPM CACO3) ",THCR,         !
003200 PIC(####.##),                                                      !
003202 AT(13,5),"* CALCIUM HARDNESS        (0)(PPM CACO3) ",CACR,         !
003204 PIC(####.##),                                                      !
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003206 AT(14,5),"  MAGNESIUM HARDNESS      (0)(PPM CACO3) ",MGCR,        !
003208 PIC(####.##),                                                     !
003210 AT(15,5),"  M ALKALINITY           (15)(PPM CACO3) ",MACR,        !
003212 PIC(####.##),                                                     !
003214 AT(16,5),"* TOTAL DISSOLVED SOLIDS (15)(PPM)       ",TDSCR,       !
003216 PIC(####.##),                                                     !
003218 AT(17,5),"  SILICA                  (0)(PPM SIO2)  ",SICR,        !
003220 PIC(####.##),                                                     !
003222 AT(18,5),"  TOTAL SUSPENDED SOLIDS  (0)(PPM)       ",TSSCR,       !
003224 PIC(####.##),                                                     !
003226 AT(19,5),"* PH                    (7.5)            ",PHCR,        !
003228 PIC(####.##),                                                     !
003230 AT(20,5),"* IRON                    (0)(PPM FE)    ",FECR,        !
003232 PIC(####.##),                                                     !
003234 AT(21,5),"* COPPER                  (0)(PPM CU)    ",CUCR,        !
003236 PIC(####.##), KEYS(BIN(0)) : PRINT
003238 DEC35 : Y$ = "QQ"
003240 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003242 IF Y$ = "E" THEN GOTO EXIT35
003244 IF Y$ = "Y" THEN GOTO START36
003246 IF Y$ = "N" THEN GOTO START35  ELSE GOTO DEC35
003248 EXIT35 : RETURN : REM SUBROUTINE EDIT1 ENDS
003250 START36 : ACCEPT                                                  !
003252 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
003254 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",      !
003256 AT(5,2), "**       FEEDWATER QUALITY OF INTEREST      **",        !
003258 AT(7,3), " A * IN FRONT OF THE ITEM INDICATES IT IS  ",            !
003260 AT(8,3), "           NEEDED PER AFP 91-41",                       !
003262 AT(10,5),"* CALCIUM HARDNESS       (PPM CACO3) ",CAFT,            !
003264 PIC(####.##),                                                     !
003266 AT(11,5),"* M ALKALINITY           (PPM CACO3) ",MAFT,            !
003268 PIC(####.##),                                                     !
003270 AT(12,5),"* P ALKALINITY           (PPM CACO3) ",PAFT,            !
003272 PIC(####.##),                                                     !
003274 AT(13,5),"* TOTAL DISSOLVED SOLIDS (PPM)       ",TDSFT,           !
003276 PIC(####.##),                                                     !
003278 AT(14,5),"* SILICA                 (PPM SIO2)  ",SIFT,            !
003280 PIC(####.##),                                                     !
003282 KEYS(BIN(0)) : PRINT
003284 DEC36 : Y$ = "QQ"
003286 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003288 IF Y$ = "E" THEN GOTO EXIT36
003290 IF Y$ = "Y" THEN GOTO START37
003292 IF Y$ = "N" THEN GOTO START36  ELSE GOTO DEC36
003294 EXIT36 : RETURN : REM SUBROUTINE EDIT1 ENDS
003296 START37 : ACCEPT                                                  !
003298 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                   !
003300 AT(3,1), "INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE",   !
003302 AT(5,2), "**         BOILER QUALITY OF INTEREST       **",        !
003304 AT(7,3), " A * IN FRONT OF THE ITEM INDICATES IT IS  ",            !
003306 AT(8,3), "             NEEDED PER AFP 91-41",                     !
003308 AT(10,1),"VALUES TAKEN FROM WATER TREATMENT LOG (AF FORM 1459)",   !
```

```
003310 AT(12,5),"* HYDROXYL ALKALINITY    (PPM CACO3) ",OHBDT,          :
003312 PIC(####.##),                                                    :
003314 AT(13,5),"* TOTAL DISSOLVED SOLIDS (PPM)       ",TDSBDT,         :
003316 PIC(####.##),                                                    :
003318 AT(14,5),"NOTE - TDS SAMPLES TAKEN FROM CONTINUOUS BLOWDOWN WHEN :
003320 POSSIBLE.",                                                      :
003322 AT(15,5),"       TSS SAMPLES SHOULD BE TAKEN FROM THE BOTTOM BLOW:
003324 DOWN.",                                                          :
003326 AT(16,5),"* PHOSPHATE              (PPM PO4)   ",PHSBDT,         :
003328 PIC(####.##),                                                    :
003330 AT(17,5),"* SULFITE                (PPM SO3)   ",SFBDT,          :
003332 PIC(####.##),                                                    :
003334 AT(18,5),"* LIGNOSULFONATE    (PPM TANNIC ACID)",LSNBDT,         :
003336 PIC(####.##),                                                    :
003338 AT(19,5),"* PH                     (PPM)       ",PHBLR,          :
003340 PIC(####.##), KEYS(BIN(0)) : PRINT
003342 DEC37 : Y$ = "QQ"
003344 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003346 IF Y$ = "E" THEN GOTO EXIT37
003348 IF Y$ = "Y" THEN GOTO START38
003350 IF Y$ = "N" THEN GOTO START37  ELSE GOTO DEC37
003352 EXIT37 : RETURN : REM SUBROUTINE EDIT1 ENDS
003354 START38 : ACCEPT                                                 :
003356 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  :
003358 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",     :
003360 AT(5,5), "   **  STEAM QUALITY OF INTEREST  **",                 :
003362 AT(7,1), "TOTAL DISSOLVED SOLIDS IN STEAM (ASSUME 0 IF PURE) =", :
003364 TDSS, PIC(####.##),                                              :
003366 AT(8,1), "               SILICA IN STEAM (ASSUME 0 IF PURE) =",  :
003368 SIS,PIC(####.##),                                                :
003370 AT(10,10),"**   CHEMICAL LEVELS MAINTAINED    **",               :
003372 AT(12,1),"SELECTED OPERATING LEVEL FOR TOTAL DISSOLVED SOLIDS (PP:
003374 M)   =",TDSBD, PIC(####.##),                                     :
003376 AT(13,1),"SELECTED OPERATING LEVEL FOR SILICA            (PPM SIO:
003378 2)   =",SIBD, PIC(####.##),                                      :
003380 AT(14,1),"SELECTED OPERATING LEVEL FOR PHOSPHATE          (PPM PO:
003382 4)   =",PHSBD, PIC(####.##),                                     :
003384 AT(15,3),"NAME OF PHOSPHATE CHEMICAL USED    ",PHS$, CH(40),     :
003386 AT(16,3),"PERCENTAGE (%) (USE MINIMUM 0.0001) OF PO4 IN CHEMICAL :
003388 USED  =",PHSPC, PIC(###.####),                                   :
003390 AT(17,3),"POUNDS OF PHOSPHATE CHEMICAL REQUIRED TO TREAT 1000 GAL:
003392 LONS OF FEEDWATER PER",                                          :
003394 AT(18,5),"PPM HARDNESS  =",PHSNHD, PIC(###.####),                :
003396 AT(19,3),"POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUN:
003398 DS OF SODIUM",                                                   :
003400 AT(20,5),"HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF PHOSPHATE C:
003402 HEMICAL  =",PHSNOH, PIC(###.####),                               :
003404 AT(22,1),"SELECTED FEEDWATER POUNDS/GALLON FOR CALCULATIONS   =",:
003406 DENSF, PIC(###.####), KEYS(BIN(0)) : PRINT
003408 IF PHSPC <= 0 OR PHSPC > 100 THEN GOTO 3412   ELSE GOTO 3410
003410 IF DENSF <= 7 OR DENSF >= 8.5 THEN GOTO 3412   ELSE GOTO DEC38
003412 PRINT "PHOSPHATE CHEMICAL PURITY OR DENSITY OF FEEDWATER OUT OF R:
```

```
003414 ANGE" : PRINT : PRINT: PRINT : GOTO START38
003416 DEC38 : Y$ = "QQ"
003418 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003420 IF Y$ = "E" THEN GOTO EXIT38
003422 IF Y$ = "Y" THEN GOTO START39
003424 IF Y$ = "N" THEN GOTO START38  ELSE GOTO DEC38
003426 EXIT38 :  RETURN : REM SUBROUTINE EDIT1 ENDS
003428 START39 : ACCEPT                                                    !
003430 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                     !
003432 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",        !
003434 AT(5,10),"** CHEMICAL LEVELS MAINTAINED (CONT) **",                  !
003436 AT(7,1), "SELECTED OPERATING LEVEL FOR HYDROXYL ALKALINITY (PPM C!
003438 ACO3)  =",OHBD, PIC(####.##),                                       !
003440 AT(8,2), "PURITY (%) OF CAUSTIC SODA USED (DRY USUALLY 98)  =",      !
003442 NAOHPC, PIC(####.##),                                               !
003444 AT(10,1),"SELECTED % OF CARBONATE ALKALINITY BREAKDOWN IN BOILER !
003446  =",CARBPC, PIC(####.##),                                           !
003448 AT(12,1),"SELECTED LIGNOSULFONATE OPERATING LEVEL (PPM TANNIC ACI!
003450 D)  =",LSNBD, PIC(####.##),                                         !
003452 AT(13,2),"PURITY (%) OF LIGNOSULFONATE CHEMICAL USED BASED ON TAN!
003454 NIC ACID CONTENT",                                                  !
003456 AT(14,2),"(ASSUME 100 UNLESS MANUFACTURER OR ACTUAL TEST INDICATE!
003458 S OTHERWISE)  =",LSNPC, PIC(####.##),                               !
003460 AT(16,1),"SELECTED SULFITE (PPM SO3) OPERATING LEVEL   =",SFBD,      !
003462 PIC(####.##),                                                       !
003464 AT(17,2),"PURITY (%) OF SULFITE CHEMICAL USED (USUALLY 90)  =",      !
003466 SFPC, PIC(####.##), KEYS(BIN(0)) : PRINT
003468 IF NAOHPC <= 0 OR CARBPC <= 0 THEN GOTO 3480   ELSE GOTO 3470
003470 IF LSNPC <= 0 OR SFPC <=0 THEN GOTO 3480   ELSE GOTO 3472
003472 IF NAOHPC > 100 OR CARBPC > 100 THEN GOTO 3480   ELSE GOTO 3474
003474 IF LSNPC > 100 OR SFPC > 100 THEN GOTO 3480   ELSE GOTO 3476
003476 IF OHBD < 170 OR OHBD > 550 THEN GOTO 3480   ELSE GOTO 3478
003478 IF LSNBD < 40 OR LSNBD > 100 THEN GOTO 3480   ELSE GOTO DEC39
003480 PRINT "TREATMENT CHEMICAL LEVELS OR PURITY OR % ALKALINITY BREAKD!
003482 OWN OUT OF RANGE" : PRINT : PRINT : GOTO START39
003484 DEC39 : Y$ = "QQ"
003486 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003488 IF Y$ = "E" THEN GOTO EXIT39
003490 IF Y$ = "Y" THEN GOTO START40
003492 IF Y$ = "N" THEN GOTO START39 ELSE GOTO DEC39
003494 EXIT39 : RETURN : REM SUBROUTINE EDIT1 ENDS
003496 START40 : ACCEPT                                                    !
003498 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                     !
003500 AT(3,1), "MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE",        !
003502 AT(5,10),"** CHEMICAL LEVELS MAINTAINED (CONT) **",                  !
003504 AT(7,3), "PURITY (%) OF CYCLOHEXYLAMINE USED (60 OR 98) =",CHAPC,!
003506 PIC(####.##),                                                       !
003508 AT(8,3), "PURITY (%) OF MORPHOLINE USED (40, 91, OR 99) =",MORPC,!
003510 PIC(####.##),                                                       !
003512 AT(10,1),"SELECTED DISTRIBUTION RATIO FOR CYCLOHEXYLAMINE  =",      !
003514 CHADR, PIC(####.##),                                                !
003516 AT(11,1),"SELECTED DISTRIBUTION RATIO FOR MORPHOLINE       =",      !
```

```
003518 MORDR, PIC(####.##), KEYS(BIN(0)) : PRINT
003520 IF CHAPC <= 0 OR CHAPC > 100 THEN GOTO 3528   ELSE GOTO 3522
003522 IF MORPC <= 0 OR MORPC > 100 THEN GOTO 3528   ELSE GOTO 3524
003524 IF CHADR < 4 OR CHADR > 10 THEN GOTO 3528   ELSE GOTO 3526
003526 IF MORDR < 0.4 OR MORDR > 1.5 THEN GOTO 3528   ELSE GOTO DEC40
003528 PRINT "TREATMENT CHEMICAL PURITY OR DISTRIBUTION RATIOS OUT OF RA!
003530 NGE" : PRINT : PRINT: PRINT : GOTO START40
003532 DEC40 : Y$ = "QQ"
003534 INPUT "     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ",Y$
003536 IF Y$ = "E" OR Y$ = "Y" THEN GOTO EXIT40
003538 IF Y$ = "N" THEN GOTO START40  ELSE GOTO DEC40
003540 EXIT40 :  RETURN : REM SUBROUTINE EDIT1 ENDS
003542 *
003544 INPUT4:
003546 *
003548 * BEGIN SUBROUTINE TO DELETE AN EXISTING DATA RECORD
003550 START41 : N = 1
003552 ACCEPT                                                          !
003554 AT(2,20),"STEAM BOILER WATER TREATMENT PROGRAM",                 !
003556 AT(4,1), "INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAM!
003558 E (KEYFIELD) OF THE DATA",                                      !
003560 AT(5,3), "RECORD YOU ARE INTERESTED IN.  YOU WILL THEN HAVE TO ST!
003562 EP THROUGH THE RECORDS",                                        !
003564 AT(6,3), "UNTIL YOU FIND THE ONE YOU WANT.",                     !
003566 AT(9,10),"COMPUTER USER ID  = ",UID$,CH(3),                      !
003568 AT(13,1),"PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
003570 OPEN NODISPLAY #1, SHARED,FILE="ESTM",LIBRARY="EIXXDATA",        !
003572 VOLUME=DEEDATAVOL$,SPACE=100
003574 IF N = 1 THEN GOTO 3576   ELSE GOTO 3578
003576 READ #1, HOLD, KEY = UID$, EOD GOTO EXIT41 : GOTO 3580
003578 START41A : READ #1, HOLD, EOD GOTO EXIT41
003580 N = N + 1
003582 GET #1 USING LYT1 , UID$,DATE$,BASEID$,BLDG$,BLR$,RID$,          !
003584 AMSL,BASE$,                                                     !
003586 CACR,CAMU,CARBPC,CHAPC,                                         !
003588 LSNBD,LSNPC,                                                    !
003590 MACR,MAFT,MAMU,MGCR,MGMU,MORPC,                                 !
003592 NAOHPC,OHBDT,OPR$,OXF,                                          !
003594 PAFT,PBLR,PDA,PHBLR,PHSBD,PHSPC,PHSNHD,PHSNOH,PHS$,             !
003596 QL,QS,RS,SIBD,SICR,SIFT,SIMU,SIS,SFBD,SFPC,                     !
003598 TDSBD,TDSCR,TDSFT,TDSMU,TDSS,TF,TSSCR,TSSMU,                    !
003600 CUCR,FECR,PHCR,THCR,THMU,DENSF,                                 !
003602 V0$,V1$,V2$,V3$,V4$,V5$,V6$,V7$,                                !
003604 CAFT,CHADR,MORDR,OHBD,                                          !
003606 LSNBDT,PHSBDT,SFBDT,TDSBDT,                                     !
003608 LBCHA,LBLSN,LBMOR,LBOH,LBPHS,LBSF,                              !
003610 LBOTHAM,LBOTHLSN,LBOTHOH,LBOTHPHS,LBOTHSF,                      !
003612 OTHAM$,OTHLSN$,OTHOH$,OTHPHS$,OTHSF$,COMMENT$
003614 START41B : Y$ = "QQ"
003616 ACCEPT                                                          !
003618 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                 !
003620 AT(3,1), "THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE !
```

```
003622 DATA RECORD OBSERVED.",                                                  !
003624 AT(5,1), "SELECT ACTION FOR RECORD OF INTEREST LISTED BELOW!",           !
003626 AT(6,5), "INPUT ACTION SELECTION ",FAC(HEX(91)),Y$,CH(1),                !
003628 AT(7,2), "(D) = DELETE THIS RECORD",                                     !
003630 AT(8,2), "(N) = GO TO NEXT RECORD",                                      !
003632 AT(9,2), "(E) = NO ACTION, EXIT TO PREVIOUS MENU",                       !
003634 AT(11,9),"RECORD OF INTEREST",                                           !
003636 AT(12,9),"COMPUTER USER ID     ",FAC(HEX(8D)),UID$,CH(3),                !
003638 AT(13,9),"TODAY'S DATE         ",FAC(HEX(8D)),DATE$,CH(6),               !
003640 AT(14,9),"BASE ID              ",FAC(HEX(8D)),BASEID$,CH(3),             !
003642 AT(15,9),"BUILDING NUMBER      ",FAC(HEX(8D)),BLDG$,CH(7),               !
003644 AT(16,9),"BOILER DESIGNATOR    ",FAC(HEX(8D)),BLR$,CH(2),                !
003646 AT(17,9),"RUN INDICATOR        ",FAC(HEX(8D)),RID$,CH(2),                !
003648 AT(18,1),"COMMENT DESCRIBING THIS DATA ",FAC(HEX(8D)),COMMENT$,          !
003650 CH(45),                                                                  !
003652 AT(20,5), "IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE!
003654  USER ID REQUEST.",                                                      !
003656 AT(22,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
003658 IF Y$ = "E" THEN GOTO EXIT41
003660 IF Y$ = "N" THEN GOTO START41A
003662 IF Y$ = "D" THEN GOTO EXIT41A  ELSE GOTO START41B
003664 EXIT41 : CLOSE #1 : RETURN : REM SUBROUTINE INPUT4 ENDS
003666 EXIT41A : DELETE #1
003668 DEC41 : Y$ = "QQ"
003670 INPUT "DO YOU WANT TO DELETE ANOTHER RECORD ( Y OR N ) ",Y$
003672 IF Y$ = "Y" THEN GOTO EXIT41B
003674 IF Y$ = "N" THEN GOTO EXIT41  ELSE GOTO DEC41
003676 EXIT41B : CLOSE #1 : GOTO START41
```

Appendix Two

CALL SUBROUTINE FOR BASIC CALCULATIONS PER
AFP 91-41 AND SYSTEM OPERATION ANALYSIS

```
000010 SUB "CALCP"
000012 * THIS SUBPROGRAM CALCULATES THE MASSFLOW QUANTITIES AND CHEMICAL
000014 *   DOSAGES FOR STEAM BOILER WATER TREATMENT USING RATED BOILER
000016 *   QUANTITIES ADJUSTED FOR ACTUAL OPERATING CONDITIONS, QUALITY
000018 *   OF AVAILABLE MAKEUP, AND QUALITY OF CONDENSATE RETURNED
000020 *   ACCORDING TO AFP 91-41, INDUSTRIAL WATER TREATMENT PROCEDURES,
000022 *   (18 SEPTEMBER 1987)
000024 *
000026 * THE MAIN PROGRAM CREATES AND MAINTAINS THE DATA FILE THAT THIS
000028 *   SUBPROGRAM ACCESSES
000030 *
000032 * A DESCRIPTION OF VARIABLES IS AVAILABLE AT THE BEGINNING OF THE
000034 *   THE MAIN PROGRAM
000036 *
000038 ***   INITIALIZE VARIABLES TO ZERO AND SET GENERAL INFO
000040 * THE WANG VS 100 COMPUTER AUTOMATICALLY INITIALIZES ALL
000042 *     VARIABLES TO ZERO
000044 LYT2 : FMT CH(3),CH(6),CH(3),CH(7),CH(2),CH(2),                    !
000046 PIC(#####),CH(20),                                                !
000048 4*PIC(####.##),                                                   !
000050 2*PIC(####.##),                                                   !
000052 6*PIC(####.##),                                                   !
000054 2*PIC(####.##),CH(15),PIC(###.####),                              !
000056 6*PIC(####.##),2*PIC(###.####),CH(40),                            !
000058 3*PIC(########.##),7*PIC(####.##),                                !
000060 8*PIC(####.##),                                                   !
000062 5*PIC(####.##),PIC(###.####),                                     !
000064 8*CH(1),POS(782),CH(45)
000066 LYT3 : FMT CH(20),       PIC(##0.####)
000068 LYT4 : FMT CH(45),     PIC(#,##0.##)
000070 LYT5 : FMT CH(50), PIC(#,###,##0.##)
000072 LYT6 : FMT CH(67), PIC(#,###,##0.##)
000074 LYT7 : FMT CH(60), PIC(#,###,##0.##)
000076 LYT8 : FMT CH(55),     PIC(#,##0.##)
000078 LYT9 : FMT CH(40), CH(20)
000080 LYT10 : FMT CH(30), CH(45)
000082 LYT11 : FMT CH(55),      PIC(##0.####)
000084 *
```

```
000086 COM AMSL,HG,PAB,PATM,PBLR,UID$ 3,IPLVOL$ 6,DEEDATAVOL$ 6
000088 DIM DATE$ 6,BASEID$ 3,BLDG$ 7,BLR$ 2,RID$ 2,                          !
000090 BASE$ 20,OPR$ 15,PHS$ 40,V0$ 1,V1$ 1,V2$ 1,V3$ 1,V4$ 1,V5$ 1,        !
000092 V6$ 1,V7$ 1,                                                          !
000094 WARNBD1$ 80,WARNBD2$ 80,WARNBD3$ 80,                                  !
000096 WARNCR1$ 80,WARNCR2$ 80,WARNCR3$ 80,WARNCR4$ 80,WARNCR5$ 80,          !
000098 WARNCR6$ 80,                                                          !
000100 WARNDA1$ 80,WARNDA2$ 80,WARNDA3$ 80,                                  !
000102 WARNF1$ 80,WARNF2$ 80,WARNF3$ 80,WARNF4$ 80,WARNF5$ 80,              !
000104 WARNMU1$ 80,WARNMU2$ 80,WARNMU3$ 80,                                  !
000106 WARNNA1$ 80,WARNNA2$ 80,WARNNA3$ 80,WARNNA4$ 80,WARNNA5$ 80,          !
000108 WARNNA6$ 80,WARNQ1$ 80,                                               !
000110 WARNQL1$ 80,WARNQL2$ 80,                                              !
000112 WARNQMU1$ 80,                                                         !
000114 WARNQS1$ 80,WARNQS2$ 80,WARNQS3$ 80,                                  !
000116 WARNT1$ 80,COMMENT$ 45
000118 *
000120 WARNBD1$ ="DANGER -INSUFFICIENT HYDROXYL ALKALINITY TO FORM HYDRO!
000122 XYAPATITE OR SERPENTINE!"
000124 WARNBD2$ ="CHEMICAL REACTIONS THIS PROGRAM IS BASED UPON WILL NOT!
000126  OCCUR!"
000128 WARNBD3$ ="CHECK BOILER PH AND HYDROXYL ALKALINITY TESTING-RESULT!
000130 S ARE INCONSISTENT."
000132 WARNCR1$ ="INVESTIGATE AND CORRECT DETRIMENTAL INLEAKAGE INTO CON!
000134 DENSATE SYSTEM!"
000136 WARNCR2$ ="LOW CONDENSATE PH INVITES IRON CORROSION."
000138 WARNCR3$ ="HIGH CONDENSATE PH CAN BE DUE TO IRON CORROSION IF NO !
000140 AMINES USED."
000142 WARNCR4$ ="IF AMINES ARE USED, HIGH CONDENSATE PH INVITES COPPER !
000144 CORROSION."
000146 WARNCR5$ ="EXCESSIVE IRON LEVELS IN CONDENSATE RETURN."
000148 WARNCR6$ ="EXCESSIVE COPPER LEVELS IN CONDENSATE RETURN."
000150 WARNDA1$ ="THE DEAERATING HEATER IS NOT BOILING PROPERLY!  CHECK !
000152 CALIBRATION OF THE"
000154 WARNDA2$ ="  GAUGES AND TEST THE OXYGEN CONTENT OF THE FEEDWATER.!
000156 "
000158 WARNDA3$ ="THE DEAERATING HEATER PRESSURE AND TEMPERATURE INDICAT!
000160 E PROPER OPERATION."
000162 WARNF1$ ="SUFFICIENT SILICA FOR MAGNESIUM REACTION TO FORM SERPEN!
000164 TINE."
000166 WARNF2$ ="WARNING-INSUFFICIENT SILICA AVAILABLE FOR MAGNESIUM REA!
000168 CTION TO FORM SERPENTINE!"
000170 WARNF3$ ="SILICA/PHOSPHATE RATIO FAVORABLE TO FORM SERPENTINE - A!
000172 FP 91-41."
000174 WARNF4$ ="WARNING-SILICA/PHOSPHATE RATIO UNFAVORABLE TO FORM SERP!
000176 ENTINE - AFP 91-41!"
000178 WARNF5$ ="MAGNESIUM HYDROXIDE WILL FORM IF SUFFICIENT HYDROXYL AL!
000180 KALINITY AVAILABLE."
000182 WARNMU1$ ="ION EXCHANGE SOFTENING IS NOT REACHING ACCEPTED STANDA!
000184 RDS!"
000186 WARNMU2$ ="DEALKALIZATION IS NOT REACHING ACCEPTED STANDARDS."
000188 WARNMU3$ ="EXPECTED NO SUSPENDED SOLIDS IN MAKEUP DUE TO PRETREAT!
```

```
000190 MENT SPECIFIED."
000192 WARNNA1$ ="FINAL STEADY STATE DOSE IS ABOUT 20 % OF THIS INITIAL !
000194 DOSE."
000196 WARNNA2$ ="COMPARE CALCULATED TO ACTUAL DOSAGES."
000198 WARNNA3$ ="NOTE THE MIXTURE RATIOS AND MAXIMUM DOSAGES ALLOWED FO!
000200 R NEUTRALIZING AMINES"
000202 WARNNA4$ ="  PER AFP 91-41."
000204 WARNNA5$ ="DO NOT USE AMINES IF STEAM COMES INTO DIRECT CONTACT W!
000206 ITH FOOD.  IMMEDIATELY    "
000208 WARNNA6$ ="HAVE SERVICES PROGRAM EQUIPMENT REPLACEMENT AS THIS IS!
000210  AGAINST STATED POLICY."
000212 WARNPHS1$ ="WARNING-WITH NO PHOSPHATE ADDED, THERE IS ALSO NOT EN!
000214 OUGH CARBONATE ALKALINITY"
000216 WARNPHS2$ ="TO PREVENT CALCIUM SULFATE SCALE!  SOFTEN THE MAKEUP !
000218 OR ADD SODA ASH (NA2CO3)!"
000220 WARNQ1$ ="COMPARE CALCULATED TO ACTUAL METERED OR LOG ENTRY VALUE!
000222 S."
000224 WARNQS1$ ="STEAM QUANTITIES NEED REEVALUATION."
000226 WARNQS2$ ="CHECK METER ACCURACY AND BEWARE OF OVERSTEAMING!"
000228 WARNQS3$ ="STEAM IS NOT PURE.  CHECK OPERATION AND TREATMENT!"
000230 WARNQL1$ ="LOSSES HIGH ENOUGH TO JUSTIFY SURVEY TO IDENTIFY AND C!
000232 ORRECT."
000234 WARNQL2$ ="ENERGY AND TREATMENT SAVINGS CAN BE SIGNIFICANT."
000236 WARNQMU1$ ="COMPARE THIS CALCULATED MAKEUP FLOW TO THE METERED VA!
000238 LUE."
000240 WARNT1$ ="COMPARE CALCULATED TO ACTUAL TESTED VALUES."
000242 *
000244 * ACCESS EXISTING FILE FOR DATA TO USE IN THESE CALCULATIONS
000246 SELECT #1,"ESTM",INDEXED,RECSIZE=826,KEYPOS=1,KEYLEN=23
000248 SELECT PAUSE 10 : REM A 1 SECOND PAUSE AFTER EACH PRINT STATEMENT!
000250                        WITHOUT A LITERAL STRING ATTACHED
000252 OPEN NODISPLAY #1, SHARED,FILE="ESTM",LIBRARY="EIXXDATA",        !
000254 VOLUME=DEEDATAVOL$,SPACE=100
000256 N = 1 : ACCEPT                                                   !
000258 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  !
000260 AT(3,1), "INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAM!
000262 E (KEYFIELD) OF THE DATA",                                       !
000264 AT(4,3), "RECORD YOU ARE INTERESTED IN.  YOU WILL THEN HAVE TO ST!
000266 EP THROUGH THE RECORDS",                                         !
000268 AT(5,3), "UNTIL YOU FIND THE ONE YOU WANT.",                      !
000270 AT(7,10),"COMPUTER USER ID  = ",UID$,CH(3),                       !
000272 AT(11,1),"NOTE - THE CALCULATIONS ARE BASED ON INITIAL MAKEUP AND!
000274  CONDENSATE QUALITIES,",                                         !
000276 AT(12,3),"AS WELL AS SYSTEM OPERATION.  ADJUST RECORD VALUES TO A!
000278 DJUST THE INPUT VALUES,",                                        !
000280 AT(13,3),"TO THE CALCULATIONS.",                                 !
000282 AT(14,3),"A DECISION FOR ONE PRINTOUT IS AVAILABLE AT THE END OF !
000284 THE RUN.",                                                       !
000286 AT(18,1),  "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0)) : PRINT
000288 IF N = 1 THEN GOTO 290   ELSE GOTO 292
000290 READ #1, HOLD, KEY = UID$, EOD GOTO EXIT1  : GOTO 294
000292 START1 : READ #1, HOLD, EOD GOTO EXIT1
```

```
000294 N = N + 1
000296 GET #1 USING LYT2 , UID$,DATE$,BASEID$,BLDG$,BLR$,RID$,          :
000298 AMSL,BASE$,                                                      :
000300 CACR,CAMU,CARBPC,CHAPC,                                          :
000302 LSNBD,LSNPC,                                                     :
000304 MACR,MAFT,MAMU,MGCR,MGMU,MORPC,                                  :
000306 NAOHPC,OHBDT,OPR$,OXF,                                           :
000308 PAFT,PBLR,PDA,PHBLR,PHSBD,PHSPC,PHSNHD,PHSNOH,PHS$,              :
000310 QL,QS,RS,SIBD,SICR,SIFT,SIMU,SIS,SFBD,SFPC,                      :
000312 TDSBD,TDSCR,TDSFT,TDSMU,TDSS,TF,TSSCR,TSSMU,                     :
000314 CUCR,FECR,PHCR,THCR,THMU,DENSF,                                  :
000316 V0$,V1$,V2$,V3$,V4$,V5$,V6$,V7$,COMMENT$
000318 START2 : Y$ = "QQ"
000320 ACCEPT                                                           :
000322 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                  :
000324 AT(3,1), "THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE :
000326 DATA RECORD OBSERVED.",                                          :
000328 AT(5,1), "SELECT ACTION FOR RECORD OF INTEREST LISTED BELOW!",   :
000330 AT(6,5), "INPUT ACTION SELECTION ",FAC(HEX(91)),Y$,CH(1),        :
000332 AT(7,2), "(S) = SELECT THIS RECORD",                             :
000334 AT(8,2), "(N) = GO TO NEXT RECORD",                              :
000336 AT(9,2), "(E) = NO ACTION, EXIT TO PREVIOUS MENU",               :
000338 AT(11,9),"RECORD OF INTEREST",                                   :
000340 AT(12,9),"COMPUTER USER ID     ",FAC(HEX(8D)),UID$,CH(3),        :
000342 AT(13,9),"TODAY'S DATE         ",FAC(HEX(8D)),DATE$,CH(6),       :
000344 AT(14,9),"BASE ID              ",FAC(HEX(8D)),BASEID$,CH(3),     :
000346 AT(15,9),"BUILDING NUMBER      ",FAC(HEX(8D)),BLDG$,CH(7),       :
000348 AT(16,9),"BOILER DESIGNATOR    ",FAC(HEX(8D)),BLR$,CH(2),        :
000350 AT(17,9),"RUN INDICATOR        ",FAC(HEX(8D)),RID$,CH(2),        :
000352 AT(18,1),"COMMENT DESCRIBING THIS DATA ",FAC(HEX(8D)),COMMENT$,  :
000354 CH(45),                                                          :
000356 AT(20,5), "IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE:
000358  USER ID REQUEST.",                                              :
000360 AT(22,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0)) : PRINT
000362 IF Y$ = "E" THEN GOTO EXIT1
000364 IF Y$ = "N" THEN GOTO START1
000366 IF Y$ = "S" THEN GOTO NEXT1  ELSE GOTO START2
000368 ***   PRETREATMENT WARNINGS
000370 *
000372 NEXT1 : PRINT"PRETREATMENT EXISTING OR ANALYZED IS AS FOLLOWS:" :!
000374 PRINT
000376 IF V0$ = "Y" THEN PRINT "          FILTER"
000378 IF V1$ = "Y" THEN PRINT "          SODIUM ZEOLITE SOFTENER"
000380 IF V2$ = "Y" THEN PRINT "          HYDROGEN ZEOLITE SOFTENER"
000382 IF V3$ = "Y" THEN PRINT "          SPLIT STREAM SOFTENER NAZ - HZ"
000384 IF V4$ = "Y" THEN PRINT "          ZEOLITE DEALKALIZER"
000386 IF V5$ = "Y" THEN PRINT "          COLD LIME-SODA SOFTENER"
000388 IF V6$ = "Y" THEN PRINT "          HOT LIME-SODA SOFTENER"
000390 IF V7$ = "Y" THEN PRINT "          DEGASIFIER"
000392 IF (V0$ <>"Y" AND V1$ <>"Y") THEN GOTO 394     ELSE GOTO 402
000394 IF (V2$ <>"Y" AND V3$ <>"Y") THEN GOTO 396     ELSE GOTO 402
000396 IF (V4$ <>"Y" AND V5$ <>"Y") THEN GOTO 398     ELSE GOTO 402
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000398 IF (V6$ <>"Y" AND V7$ <>"Y") THEN GOTO 400     ELSE GOTO 402
000400 PRINT "          NO PRETREATMENT SPECIFIED" : PRINT
000402 IF (THMU > 1 OR CAMU > 1) THEN GOTO 404    ELSE GOTO  410
000404 IF (V1$="Y" OR V2$="Y" OR V3$="Y") THEN GOTO 408    ELSE GOTO    !
000406 410
000408 PRINT WARNMU1$
000410 IF (MAMU > 50 OR MAMU < 10) THEN GOTO 412    ELSE GOTO 418
000412 IF (V3$="Y" OR V4$="Y" OR V7$="Y") THEN GOTO 416    ELSE GOTO    !
000414 418
000416 PRINT WARNMU2$
000418 IF TSSMU > 0 THEN GOTO 420    ELSE GOTO 428
000420 IF (V0$="Y" OR V1$="Y" OR V2$="Y") THEN GOTO 426    ELSE GOTO    !
000422 424
000424 IF (V3$="Y" OR V4$="Y") THEN GOTO 426    ELSE GOTO 428
000426 PRINT WARNMU3$
000428 IF (TDSCR > 10 OR SICR > 0 OR TSSCR > 10) THEN GOTO 434    ELSE  !
000430 GOTO 432
000432 IF (THCR > 0 OR CACR > 0) THEN GOTO 434    ELSE GOTO 436
000434 PRINT WARNCR1$
000436 IF PHCR < 7.5 THEN GOTO 438    ELSE GOTO 440
000438 PRINT WARNCR2$
000440 IF PHCR > 8.0 THEN GOTO 442    ELSE GOTO 444
000442 PRINT WARNCR3$ : PRINT WARNCR4$
000444 IF FECR > .1 THEN GOTO 446    ELSE GOTO 448
000446 PRINT WARNCR5$
000448 IF CUCR > 0.01 THEN GOTO 450    ELSE GOTO 452
000450 PRINT WARNCR6$
000452 IF (PHBLR < 11.0 AND OHBDT < 50) THEN GOTO 454    ELSE GOTO 456
000454 PRINT WARNBD1$ : PRINT WARNBD2$
000456 IF (PHBLR < 11.0 AND OHBDT > 50) OR (PHBLR > 11.0 AND OHBDT < 50)!
000458 THEN GOTO 460    ELSE GOTO 462
000460 PRINT WARNBD3$
000462 PRINT : PRINT
000464 ***   DETERMINE ACTUAL MASSFLOWS
000466 *
000468 CALL "ENTHALPY"
000470 FE = (HG - (TF-32))/970.3
000472 QSM = RS/FE
000474 QCR = QS - QL
000476 PRINT USING LYT5 ,                                                  !
000478 "RATED EVAPORATION (POUNDS/HOUR)              =     ",RS
000480 PRINT USING LYT5 ,                                                  !
000482 "MAXIMUM EVAPORATION (POUNDS/HOUR QS)         =     ",QSM
000484 PRINT USING LYT7 ,                                                  !
000486 "ACTUAL EVAPORATION TO BE INVESTIGATED (POUNDS/HOUR)     =  ",QS
000488 IF (QS > QSM OR QS > RS OR RS < QSM) THEN GOTO 492    ELSE       !
000490 GOTO 494
000492 PRINT WARNQS1$ : PRINT WARNQS2$
000494 PRINT : PRINT
000496 IF TDSS > 0 OR SIS > 0 THEN GOTO 498     ELSE GOTO 500
000498 PRINT WARNQS3$
000500 PRINT
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000502 PRINT USING LYT7 ,                                                    !
000504 "ESTIMATED STEAM AND CONDENSATE LOSSES (POUNDS/HOUR QL)  =  ",QL
000506 PRINT "NOTE THAT A STRICT AFP 91-41 CALCULATION WOULD SET QL = 0"
000508 IF QL > (0.05 * QS) THEN GOTO 510     ELSE GOTO 512
000510 PRINT WARNQL1$ : PRINT WARNQL2$
000512 PRINT
000514 PRINT USING LYT5 ,                                                    !
000516 "CONDENSATE RETURNED (POUNDS/HOUR QCR)       =     ",QCR
000518 PRINT
000520 ***   MAKEUP BASED UPON TOTAL DISSOLVED SOLIDS
000522 *
000524 QMUTDS = (TDSCR*QCR - TDSS*QS + TDSBD*QL) / (TDSBD - TDSMU)
000526 PRINT USING LYT5 ,                                                    !
000528 "MAKEUP (POUNDS/HOUR QMU) BASED ON TDS       =     ",QMUTDS
000530 ***   MAKEUP BASED UPON SILICA
000532 *
000534 QMUSI = (SICR*QCR - SIS*QS + SIBD*QL) / (SIBD - SIMU)
000536 PRINT USING LYT5 ,                                                    !
000538 "MAKEUP (POUNDS/HOUR QMU) BASED ON SIO2      =     ",QMUSI
000540 IF QMUTDS > QMUSI THEN GOTO 552
000542 IF QMUSI > QMUTDS THEN GOTO 560
000544 QMU = QMUTDS
000546 PRINT USING LYT6 ,                                                    !
000548 "MAKEUP EQUALLY CONSTRAINED BY TDS AND SIO2 (POUNDS/HOUR QMU)         !
000550  = ",QMU : GOTO 566
000552 QMU = QMUTDS
000554 PRINT USING LYT5 ,                                                    !
000556 "MAKEUP LIMITED BY TDS (POUNDS/HOUR QMU)     =     ",QMU
000558 GOTO 566
000560 QMU = QMUSI
000562 PRINT USING LYT5 ,                                                    !
000564 "MAKEUP LIMITED BY SIO2 (POUNDS/HOUR QMU)    =     ",QMU
000566 PRINT WARNQMU1$ : PRINT : PRINT
000568 ***   DETERMINE FEEDWATER QUALITY
000570 *
000572 QF = QCR + QMU
000574 PRINT USING LYT5 ,                                                    !
000576 "FEEDWATER (POUNDS/HOUR QF)                  =     ",QF
000578 PRINT WARNQ1$ : PRINT
000580 TDSF = (TDSCR*QCR + TDSMU*QMU) / QF
000582 PRINT USING LYT8 ,                                                    !
000584 "CALCULATED TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM)  =",TDSF
000586 PRINT USING LYT8 ,                                                    !
000588 "TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) BY TEST     =",TDSFT
000590 PRINT WARNT1$ : PRINT : PRINT
000592 SIF = (SICR*QCR + SIMU*QMU) / QF
000594 PRINT USING LYT8 ,                                                    !
000596 "CALCULATED SILICA IN FEEDWATER (PPM SIO2)             =",SIF
000598 PRINT USING LYT8 ,                                                    !
000600 "SILICA IN FEEDWATER (PPM SIO2) BY TEST                =",SIFT
000602 PRINT WARNT1$ : PRINT : PRINT
000604 ***   DETERMINE CYCLES OF CONCENTRATION
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000606 *
000608 CYCTDSD = TDSBD / TDSF
000610 PRINT USING LYT5 ,                                                    !
000612 "CYCLES BASED ON TDS - DESIGN LIMIT          =     ",CYCTDSD
000614 **  THE FOLLOWING SETS CYCLES TO A VERY LARGE NUMBER IF NO SILICA
000616 **  IS PRESENT IN THE FEEDWATER
000618 IF SIF = 0 THEN CYCSID = 1000000
000620 IF SIF = 0 THEN PRINT "     BOILER IS NOT SILICA LIMITED!"
000622 IF SIF = 0 THEN GOTO 630
000624 CYCSID = SIBD / SIF
000626 PRINT USING LYT5 ,                                                    !
000628 "CYCLES BASED ON SILICA - DESIGN LIMIT       =     ",CYCSID
000630 IF CYCTDSD <= CYCSID THEN CYC = CYCTDSD ELSE CYC = CYCSID
000632 PRINT USING LYT5 ,                                                    !
000634 "OPERATING CYCLES OF CONCENTRATION           =     ",CYC
000636 PRINT : PRINT
000638 BLRTDS = TDSF * CYC
000640 PRINT USING LYT5 ,                                                    !
000642 "OPERATING BOILER TDS                        =     ",BLRTDS
000644 BLRSI = SIF * CYC
000646 PRINT USING LYT5 ,                                                    !
000648 "OPERATING BOILER SILICA                     =     ",BLRSI
000650 PRINT : PRINT
000652 *****     DETERMINE BLOWDOWN
000654 *
000656 PRINT "  BLOWDOWN IS TAKEN FROM BOTTOM OF MUD DRUM (100%) OR"
000658 PRINT "    FROM CONTINUOUS LINE AT STEAM WATER INTERFACE (90%)"
000660 PRINT "    AND BOTTOM OF MUD DRUM (10%)"
000662 PRINT
000664 QBD = QMU - QL
000666 PRINT USING LYT5 ,                                                    !
000668 "BLOWDOWN (POUNDS/HOUR QBD: QMU - QL)        =     ",QBD
000670 QBD = QS / (CYC - 1)
000672 PRINT USING LYT5 ,                                                    !
000674 "BLOWDOWN (POUNDS/HOUR QBD: QS/(CYC-1))      =     ",QBD
000676 PRINT WARNQ1$ : PRINT : PRINT
000678 *****     DETERMINE PHOSPHATE DOSAGE
000680 *
000682 PRINT "PHOSPHATE CHEMICAL USED  ",PHS$
000684 PRINT USING LYT8 ,                                                    !
000686 "PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL      =     ",PHSPC
000688 PRINT "POUNDS OF PHOSPHATE CHEMICAL REQUIRED TO TREAT 1,000 GALLO!
000690 NS OF FEEDWATER PER   "
000692 PRINT USING LYT3 ,                                                    !
000694 "PPM HARDNESS  =     ",PHSNHD
000696 PRINT "POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS !
000698 OF PHOSPHATE CHEMICAL "
000700 PRINT USING LYT3 ,                                                    !
000702 "               =     ",PHSNOH
000704 PRINT
000706 PRINT USING LYT5 ,                                                    !
000708 "RESIDUAL PO4 DESIRED IN BOILER    (PPM PO4)    =  ",PHSBD
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000710 PHSWR = (QBD * 24 * PHSBD * 100) / (PHSPC * 997504.12)
000712 PRINT USING LYT5 ,                                                    !
000714 "POUNDS OF PHOSPHATE CHEMICAL/DAY FOR RESIDUAL  =  ",PHSWR
000716 THF = (THMU * QMU + THCR * QCR) / QF
000718 PRINT USING LYT5 ,                                                    !
000720 "CALCULATED FEEDWATER TOTAL HARDNESS (PPM CACO3) = ",THF
000722 PHSWHD = (THF * QF * 24 * PHSNHD) / (DENSF * 1000)
000724 PRINT USING LYT5 ,                                                    !
000726 "POUNDS OF PO4 CHEMICAL/DAY FOR HARDNESS-AFP 91-41=",PHSWHD
000728 PHSW = PHSWR + PHSWHD
000730 PRINT USING LYT5 ,                                                    !
000732 "TOTAL POUNDS OF PHOSPHATE CHEMICAL/DAY-AFP 91-41 =",PHSW
000734 PRINT : PRINT
000736 *****     DETERMINE THE CAUSTIC SODA DOSAGE
000738 *
000740 NAOHWPH = PHSW * PHSNOH / NAOHPC
000742 PRINT USING LYT5 ,                                                    !
000744 "NAOH POUNDS/DAY FOR PO4 HYDROLYSIS - AFP 91-41 =  ",NAOHWPH
000746 NAOHW = NAOHWPH
000748 PRINT USING LYT5 ,                                                    !
000750 "PURITY (%) OF CAUSTIC SODA USED                 =  ",NAOHPC
000752 PRINT USING LYT5 ,                                                    !
000754 "TOTAL CAUSTIC SODA POUNDS/DAY - AFP 91-41       =  ",NAOHW
000756 PRINT : PRINT
000758 MGF = (MGMU * QMU + MGCR * QCR) / QF
000760 PRINT USING LYT5 ,                                                    !
000762 "CALCULATED MAGNESIUM HARDNESS IN FEEDWATER      =  ",MGF
000764 PRINT WARNT1$ : PRINT
000766 SINHD = (MGF*2/3*0.24*60.1/24.3) + 0.5*(PHSWR*997504.12*PHSPC)/       !
000768 (100*24*QF)
000770 PRINT USING LYT5 ,                                                    !
000772 "CALCULATED SILICA IN FEEDWATER                  =  ",SIF
000774 PRINT USING LYT5 ,                                                    !
000776 "SILICA IN FEEDWATER BY TEST                     =  ",SIFT
000778 PRINT WARNT1$ : PRINT
000780 PRINT USING LYT5 ,                                                    !
000782 "FEEDWATER SILICA NEEDED FOR MAGNESIUM REACTIONS = ",SINHD
000784 IF SIF > SINHD THEN GOTO 786     ELSE GOTO 788
000786 PRINT WARNF1$ : PRINT : GOTO 790
000788 PRINT WARNF2$ : PRINT
000790 IF PHSW = 0 THEN GOTO 804
000792 IF BLRSI >= 0.5 *(PHSWR*PHSPC*997504.12)/(QBD*24*100) THEN            !
000794 GOTO 796    ELSE GOTO 798
000796 PRINT WARNF3$ : PRINT : GOTO 800
000798 PRINT WARNF4$ : PRINT WARNF5$ : PRINT : PRINT
000800 ***  DETERMINE FEEDWATER ALKALINITY QUANTITIES
000802 *
000804 MAF = (MAMU * QMU + MACR * QCR) / QF
000806 IF PAFT = MAF THEN GOTO 808     ELSE GOTO 810
000808 OHF = MAF : CARBF = 0 : BICARBF = 0 : GOTO 824
000810 IF PAFT > (.5 * MAF) THEN GOTO 812     ELSE GOTO 816
000812 OHF = 2 * PAFT : CARBF = 2 * (MAF - PAFT) : BICARBF = 0 : GOTO        !
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000814 824
000816 IF PAFT = 0 THEN GOTO 818     ELSE GOTO 820
000818 OHF = 0 : CARBF = 0 : BICARBF = MAF : GOTO 824
000820 IF PAFT < (.5 * MAF) THEN GOTO 822
000822 OHF = 0 : CARBF = 2 * PAFT : BICARBF = MAF - (2 * PAFT)
000824 ***   DETERMINE LIGNOSULFONATE DOSAGE
000826 *
000828 LSNWR = (24 * QBD * LSNBD * LSNPC) / (997504.12 * 100)
000830 PRINT USING LYT4 ,                                                    !
000832 "RESIDUAL PPM LIGNOSULFONATE DESIRED    =     ",LSNBD
000834 PRINT USING LYT4 ,                                                   !
000836 "PURITY (%) OF LIGNOSULFONATE CHEMICAL  =     ",LSNPC
000838 PRINT USING LYT5 ,                                                   !
000840 "LIGNOSULFONATE POUNDS/DAY FOR RESIDUAL (MINIMUM) =",LSNWR
000842 LSNWMAF = (24 * QBD * .2 * MAF * LSNPC) / (997504.12 * 100)
000844 PRINT USING LYT5 ,                                                   !
000846 "LIGNOSULFONATE DOSAGE FOR FDWTR 20 % M ALKALINITY=",LSNWMAF
000848 IF LSNWR >= LSNWMAF THEN LSNW = LSNWR
000850 IF LSNWR < LSNWMAF THEN LSNW = LSNWMAF
000852 PRINT USING LYT5 ,                                                   !
000854 "LIGNOSULFONATE DOSAGE REQUIRED PER DAY      =     ",LSNW
000856 PRINT : PRINT
000858 ***   DETERMINE SULFITE DOSAGE
000860 *
000862 *  GOSUB TO TEST DEAERATING HEATER FOR PROPER OPERATION
000864 GOSUB DAOPS
000866 SFWR = 24 * QBD * SFBD * 1.575 * 100 / (997504.12 * SFPC)
000868 PRINT USING LYT4 ,                                                   !
000870 "RESIDUAL SULFITE (PPM SO3) DESIRED     =     ",SFBD
000872 PRINT USING LYT4 ,                                                   !
000874 "PURITY (%) OF SULFITE CHEMICAL         =     ",SFPC
000876 PRINT USING LYT5 ,                                                   !
000878 "SODIUM SULFITE NEEDED FOR RESIDUAL           =     ",SFWR
000880 SFW = SFWR
000882 PRINT USING LYT5 ,                                                   !
000884 "SODIUM SULFITE REQUIRED (POUNDS/DAY)         =     ",SFW
000886 PRINT : PRINT
000888 ***   DETERMINE NEUTRALIZING AMINE DOSAGE
000890 *       FOR A 50/50 MIXTURE OF CYCLOHEXYLAMINE AND MORPHOLINE
000892 *
000894 CDOF = (BICARBF * (1 + CARBPC/100) / 2 * 1.22 * 44/61) +             !
000896 (CARBF * CARBPC/100 * 0.6 * 44/60)
000898 PRINT USING LYT5 ,                                                   !
000900 "CALCULATED M ALKALINITY IN FEEDWATER          =     ",MAF
000902 PRINT USING LYT5 ,                                                   !
000904 "M ALKALINITY IN FEEDWATER BY TEST            =     ",MAFT
000906 PRINT WARNT1$ : PRINT
000908 PRINT USING LYT5 ,                                                   !
000910 "P ALKALINITY IN FEEDWATER BY TEST            =     ",PAFT
000912 PRINT USING LYT5 ,                                                   !
000914 "BICARBONATE ALKALINITY IN FEEDWATER          =     ",BICARBF
000916 PRINT USING LYT5 ,                                                   !
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000918 "CARBONATE ALKALINITY IN FEEDWATER          =     ",CARBF
000920 IF PHSW = 0 AND CAF > (0.5*BICARBF*1.22/61+CARBF*0.6/60)*40.1/.4*!
000922 (100-CARBPC)/100 THEN GOTO 924     ELSE GOTO 926
000924 PRINT WARNPHS1$ : PRINT WARNPHS2$ : PRINT
000926 PRINT USING LYT5 ,                                                !
000928 "CARBON DIOXIDE (PPM CO2) EQUIV IN FEEDWATER =     ",CDOF
000930 PRINT
000932 CHAF = 1.12 * CDOF
000934 MORF = 0.99 * CDOF
000936 CHAW = 24 * QF * CHAF / (CHAPC/100 * 997504.12)
000938 MORW = 24 * QF * MORF / (MORPC/100 * 997504.12)
000940 PRINT USING LYT5 ,                                                !
000942 "CYCLOHEXYLAMINE DOSAGE (LB/DAY) (50/50 MIX) =     ",CHAW
000944 PRINT USING LYT5 ,                                                !
000946 "MORPHOLINE DOSAGE (LB/DAY)      (50/50 MIX) =     ",MORW
000948 PRINT WARNNA1$ : PRINT WARNNA2$ : PRINT
000950 PRINT WARNNA3$ : PRINT WARNNA4$ : PRINT
000952 PRINT WARNNA5$ :PRINT WARNNA6$ :PRINT:PRINT:PRINT:PRINT:PRINT
000954 DEC1 : Y$ = "QQ"
000956 ACCEPT                                                            !
000958 AT(5,5), "DO YOU WANT A PRINTOUT OF THIS RUN ? ",Y$,CH(1),         !
000960 AT(7,5), "  (Y) IF YOU WANT A PRINTOUT",                           !
000962 AT(8,5), "  (N) IF YOU WANT TO RETURN TO PREVIOUS MENU",           !
000964 AT(11,1),  "PRESS <ENTER> TO CONTINUE",                           !
000966 AT(15,1),"NOTE - TWO BELLS INDICATE PRINT FILE ACCESSED",         !
000968 AT(16,1),"       SCREEN THEN RETURNS TO PREVIOUS MENU",           !
000970 KEYS(BIN(0))
000972 IF Y$ = "Y" THEN GOTO NEXT2
000974 IF Y$ = "N" THEN GOTO EXIT1 ELSE GOTO DEC1
000976 NEXT2 : DISPLAY BELL : DISPLAY BELL : SELECT PAUSE : GOTO PRINTRUN
000978 EXIT1 : SELECT PAUSE 10 : CLOSE #1 : END
000980 *
000982 DAOPS:
000984 *
000986 ***   SUBROUTINE TO DETERMINE DEAERATING HEATER OPERATION
000988 IF PDA =  0.0 THEN GOTO 990     ELSE GOTO 994
000990 IF TF >= (209.99 - AMSL/500) AND TF <= (213.99 - AMSL/500) THEN  !
000992 GOTO 1242    ELSE GOTO 1234
000994 IF PDA =  0.5 THEN GOTO 996     ELSE GOTO 1000
000996 IF TF >= (211.67 - AMSL/500) AND TF <= (215.67 - AMSL/500) THEN  !
000998 GOTO 1242    ELSE GOTO 1234
001000 IF PDA =  1.0 THEN GOTO 996     ELSE GOTO 1006
001002 IF TF >= (213.31 - AMSL/500) AND TF <= (217.31 - AMSL/500) THEN  !
001004 GOTO 1242    ELSE GOTO 1234
001006 IF PDA =  1.5 THEN GOTO 1008    ELSE GOTO 1012
001008 IF TF >= (214.92 - AMSL/500) AND TF <= (218.92 - AMSL/500) THEN  !
001010 GOTO 1242    ELSE GOTO 1234
001012 IF PDA =  2.0 THEN GOTO 1014    ELSE GOTO 1018
001014 IF TF >= (216.48 - AMSL/500) AND TF <= (220.48 - AMSL/500) THEN  !
001016 GOTO 1242    ELSE GOTO 1234
001018 IF PDA =  2.5 THEN GOTO 1020    ELSE GOTO 1024
001020 IF TF >= (218.01 - AMSL/500) AND TF <= (222.01 - AMSL/500) THEN  !
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001022 GOTO 1242    ELSE GOTO 1234
001024 IF PDA =  3.0 THEN GOTO 1026    ELSE GOTO 1030
001026 IF TF >= (219.50 - AMSL/500) AND TF <= (223.50 - AMSL/500) THEN  !
001028 GOTO 1242    ELSE GOTO 1234
001030 IF PDA =  3.5 THEN GOTO 1032    ELSE GOTO 1036
001032 IF TF >= (220.96 - AMSL/500) AND TF <= (224.96 - AMSL/500) THEN  !
001034 GOTO 1242    ELSE GOTO 1234
001036 IF PDA =  4.0 THEN GOTO 1038    ELSE GOTO 1042
001038 IF TF >= (222.38 - AMSL/500) AND TF <= (224.38 - AMSL/500) THEN  !
001040 GOTO 1242    ELSE GOTO 1234
001042 IF PDA =  4.5 THEN GOTO 1044    ELSE GOTO 1048
001044 IF TF >= (223.77 - AMSL/500) AND TF <= (227.77 - AMSL/500) THEN  !
001046 GOTO 1242    ELSE GOTO 1234
001048 IF PDA =  5.0 THEN GOTO 1050    ELSE GOTO 1054
001050 IF TF >= (225.13 - AMSL/500) AND TF <= (229.13 - AMSL/500) THEN  !
001052 GOTO 1242    ELSE GOTO 1234
001054 IF PDA =  5.5 THEN GOTO 1056    ELSE GOTO 1060
001056 IF TF >= (226.47 - AMSL/500) AND TF <= (230.47 - AMSL/500) THEN  !
001058 GOTO 1242    ELSE GOTO 1234
001060 IF PDA =  6.0 THEN GOTO 1062    ELSE GOTO 1066
001062 IF TF >= (227.78 - AMSL/500) AND TF <= (231.78 - AMSL/500) THEN  !
001064 GOTO 1242    ELSE GOTO 1234
001066 IF PDA =  6.5 THEN GOTO 1068    ELSE GOTO 1072
001068 IF TF >= (229.06 - AMSL/500) AND TF <= (233.06 - AMSL/500) THEN  !
001070 GOTO 1242    ELSE GOTO 1234
001072 IF PDA =  7.0 THEN GOTO 1074    ELSE GOTO 1078
001074 IF TF >= (230.32 - AMSL/500) AND TF <= (234.32 - AMSL/500) THEN  !
001076 GOTO 1242    ELSE GOTO 1234
001078 IF PDA =  7.5 THEN GOTO 1080    ELSE GOTO 1084
001080 IF TF >= (231.55 - AMSL/500) AND TF <= (235.55 - AMSL/500) THEN  !
001082 GOTO 1242    ELSE GOTO 1234
001084 IF PDA =  8.0 THEN GOTO 1086    ELSE GOTO 1090
001086 IF TF >= (232.76 - AMSL/500) AND TF <= (236.76 - AMSL/500) THEN  !
001088 GOTO 1242    ELSE GOTO 1234
001090 IF PDA =  8.5 THEN GOTO 1092    ELSE GOTO 1096
001092 IF TF >= (233.95 - AMSL/500) AND TF <= (237.95 - AMSL/500) THEN  !
001094 GOTO 1242    ELSE GOTO 1234
001096 IF PDA =  9.0 THEN GOTO 1098    ELSE GOTO 1102
001098 IF TF >= (235.11 - AMSL/500) AND TF <= (239.11 - AMSL/500) THEN  !
001100 GOTO 1242    ELSE GOTO 1234
001102 IF PDA =  9.5 THEN GOTO 1104    ELSE GOTO 1108
001104 IF TF >= (236.26 - AMSL/500) AND TF <= (240.26 - AMSL/500) THEN  !
001106 GOTO 1242    ELSE GOTO 1234
001108 IF PDA = 10.0 THEN GOTO 1110    ELSE GOTO 1114
001110 IF TF >= (237.39 - AMSL/500) AND TF <= (241.39 - AMSL/500) THEN  !
001112 GOTO 1242    ELSE GOTO 1234
001114 IF PDA = 10.5 THEN GOTO 1116    ELSE GOTO 1120
001116 IF TF >= (238.51 - AMSL/500) AND TF <= (242.51 - AMSL/500) THEN  !
001118 GOTO 1242    ELSE GOTO 1234
001120 IF PDA = 11.0 THEN GOTO 1122    ELSE GOTO 1126
001122 IF TF >= (239.60 - AMSL/500) AND TF <= (243.60 - AMSL/500) THEN  !
001124 GOTO 1242    ELSE GOTO 1234
```

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001126 IF PDA = 11.5 THEN GOTO 1128    ELSE GOTO 1132
001128 IF TF >= (240.67 - AMSL/500) AND TF <= (244.67 - AMSL/500) THEN  !
001130 GOTO 1242    ELSE GOTO 1234
001132 IF PDA = 12.0 THEN GOTO 1134    ELSE GOTO 1138
001134 IF TF >= (241.73 - AMSL/500) AND TF <= (245.73 - AMSL/500) THEN  !
001136 GOTO 1242    ELSE GOTO 1234
001138 IF PDA = 12.5 THEN GOTO 1140    ELSE GOTO 1144
001140 IF TF >= (242.77 - AMSL/500) AND TF <= (246.77 - AMSL/500) THEN  !
001142 GOTO 1242    ELSE GOTO 1234
001144 IF PDA = 13.0 THEN GOTO 1146    ELSE GOTO 1150
001146 IF TF >= (243.80 - AMSL/500) AND TF <= (247.80 - AMSL/500) THEN  !
001148 GOTO 1242    ELSE GOTO 1234
001150 IF PDA = 13.5 THEN GOTO 1152    ELSE GOTO 1156
001152 IF TF >= (244.81 - AMSL/500) AND TF <= (248.81 - AMSL/500) THEN  !
001154 GOTO 1242    ELSE GOTO 1234
001156 IF PDA = 14.0 THEN GOTO 1158    ELSE GOTO 1162
001158 IF TF >= (245.81 - AMSL/500) AND TF <= (249.81 - AMSL/500) THEN  !
001160 GOTO 1242    ELSE GOTO 1234
001162 IF PDA = 14.5 THEN GOTO 1164    ELSE GOTO 1168
001164 IF TF >= (246.79 - AMSL/500) AND TF <= (250.79 - AMSL/500) THEN  !
001166 GOTO 1242    ELSE GOTO 1234
001168 IF PDA = 15.0 THEN GOTO 1170    ELSE GOTO 1174
001170 IF TF >= (247.75 - AMSL/500) AND TF <= (251.75 - AMSL/500) THEN  !
001172 GOTO 1242    ELSE GOTO 1234
001174 IF PDA = 15.5 THEN GOTO 1176    ELSE GOTO 1180
001176 IF TF >= (248.71 - AMSL/500) AND TF <= (252.71 - AMSL/500) THEN  !
001178 GOTO 1242    ELSE GOTO 1234
001180 IF PDA = 16.0 THEN GOTO 1182    ELSE GOTO 1186
001182 IF TF >= (249.66 - AMSL/500) AND TF <= (253.66 - AMSL/500) THEN  !
001184 GOTO 1242    ELSE GOTO 1234
001186 IF PDA = 16.5 THEN GOTO 1188    ELSE GOTO 1192
001188 IF TF >= (250.59 - AMSL/500) AND TF <= (254.59 - AMSL/500) THEN  !
001190 GOTO 1242    ELSE GOTO 1234
001192 IF PDA = 17.0 THEN GOTO 1194    ELSE GOTO 1198
001194 IF TF >= (251.50 - AMSL/500) AND TF <= (255.50 - AMSL/500) THEN  !
001196 GOTO 1242    ELSE GOTO 1234
001198 IF PDA = 17.5 THEN GOTO 1200    ELSE GOTO 1204
001200 IF TF >= (252.41 - AMSL/500) AND TF <= (256.41 - AMSL/500) THEN  !
001202 GOTO 1242    ELSE GOTO 1234
001204 IF PDA = 18.0 THEN GOTO 1206    ELSE GOTO 1210
001206 IF TF >= (253.31 - AMSL/500) AND TF <= (257.31 - AMSL/500) THEN  !
001208 GOTO 1242    ELSE GOTO 1234
001210 IF PDA = 18.5 THEN GOTO 1212    ELSE GOTO 1216
001212 IF TF >= (254.19 - AMSL/500) AND TF <= (258.19 - AMSL/500) THEN  !
001214 GOTO 1242    ELSE GOTO 1234
001216 IF PDA = 19.0 THEN GOTO 1218    ELSE GOTO 1222
001218 IF TF >= (255.06 - AMSL/500) AND TF <= (259.06 - AMSL/500) THEN  !
001220 GOTO 1242    ELSE GOTO 1234
001222 IF PDA = 19.5 THEN GOTO 1224    ELSE GOTO 1228
001224 IF TF >= (255.93 - AMSL/500) AND TF <= (259.93 - AMSL/500) THEN  !
001226 GOTO 1242    ELSE GOTO 1234
001228 IF PDA = 20.0 THEN GOTO 1230
```

```
001230 IF TF >=(256.78 - AMSL/500) AND TF <=(260.78 - AMSL/500) THEN    !
001232 GOTO 1242     ELSE GOTO 1234
001234 PRINT WARNDA1$ : PRINT WARNDA2$
001236 PRINT USING LYT11,                                              !
001238 "DESIGN LIMIT PPM O2 FROM DEAERATOR NOT ACHIEVED  =     ",OXF
001240 PRINT : RETURN : REM SUBROUTINE DAOPS ENDS
001242 PRINT WARNDA3$
001244 PRINT USING LYT11,                                              !
001246 "DESIGN LIMITED EFFLUENT PPM O2 FROM DEAERATOR    =     ",OXF
001248 PRINT : RETURN : REM SUBROUTINE DAOPS ENDS
001250 ***   SUBROUTINE TO PROVIDE PRINTOUT OF RESULTS
001252 *
001254 PRINTRUN : SELECT PRINTER
001256 PRINT PAGE
001258 PRINT "                    ACSC/AFESC/AFIT"
001260 PRINT "         PROGRAM FOR STEAM BOILER WATER TREATMENT"
001262 PRINT "          COMPUTATION OF DAILY CHEMICAL DOSAGES"
001264 PRINT "             AND BASIC ANALYSIS IAW AFP 91-41"
001266 PRINT
001268 PRINT "DAILY DOSAGES CALCULATED ARE INITIAL VALUES ONLY.  TEST RE!
001270 SIDUALS AND ADJUST"
001272 PRINT "DOSAGES AS SYSTEM STABILIZES TO ITS FINAL OPERATING POINT."
001274 PRINT
001276 PRINT USING LYT9 ,                                              !
001278 "INSTALLATION WHERE BOILER IS LOCATED    ",BASE$
001280 PRINT USING LYT9 ,                                              !
001282 "BUILDING NUMBER WHERE BOILER LOCATED    ",BLDG$
001284 PRINT USING LYT9 ,                                              !
001286 "BOILER DESIGNATION                      ",BLR$
001288 PRINT USING LYT9 ,                                              !
001290 "NAME OF PERSON MAKING THIS RUN          ",OPR$
001292 PRINT USING LYT10 ,                                             !
001294 "COMMENT DESCRIBING THIS DATA  ",COMMENT$
001296 PRINT
001298 PRINT"**  PRETREATMENT (EXISTING OR ANALYZED) IS AS FOLLOWS:  **"
001300 PRINT
001302 IF V0$ = "Y" THEN PRINT "         FILTER"
001304 IF V1$ = "Y" THEN PRINT "         SODIUM ZEOLITE SOFTENER"
001306 IF V2$ = "Y" THEN PRINT "         HYDROGEN ZEOLITE SOFTENER"
001308 IF V3$ = "Y" THEN PRINT "         SPLIT STREAM SOFTENER NAZ - HZ"
001310 IF V4$ = "Y" THEN PRINT "         ZEOLITE DEALKALIZER"
001312 IF V5$ = "Y" THEN PRINT "         COLD LIME-SODA SOFTENER"
001314 IF V6$ = "Y" THEN PRINT "         HOT LIME-SODA SOFTENER"
001316 IF V7$ = "Y" THEN PRINT "         DEGASIFIER"
001318 IF (V0$ <>"Y" AND V1$ <>"Y") THEN GOTO 1320    ELSE GOTO 1328
001320 IF (V2$ <>"Y" AND V3$ <>"Y") THEN GOTO 1322    ELSE GOTO 1328
001322 IF (V4$ <>"Y" AND V5$ <>"Y") THEN GOTO 1324    ELSE GOTO 1328
001324 IF (V6$ <>"Y" AND V7$ <>"Y") THEN GOTO 1326    ELSE GOTO 1328
001326 PRINT "         NO PRETREATMENT SPECIFIED" : PRINT
001328 PRINT
001330 PRINT "*****     MAKEUP WATER QUALITY OF INTEREST     *****"
001332 PRINT "*****          AFTER ALL PRETREATMENT          *****"
```

```
001334 PRINT
001336 PRINT USING LYT4 ,                                                    !
001338 "TOTAL HARDNESS              (PPM CACO3)     ",THMU
001340 PRINT USING LYT4 ,                                                    !
001342 "CALCIUM HARDNESS            (PPM CACO3)     ",CAMU
001344 PRINT USING LYT4 ,                                                    !
001346 "MAGNESIUM HARDNESS          (PPM CACO3)     ",MGMU
001348 PRINT USING LYT4 ,                                                    !
001350 "M ALKALINITY                (PPM CACO3)     ",MAMU
001352 PRINT USING LYT4 ,                                                    !
001354 "TOTAL DISSOLVED SOLIDS      (PPM)           ",TDSMU
001356 PRINT USING LYT4 ,                                                    !
001358 "SILICA                      (PPM SIO2)      ",SIMU
001360 PRINT USING LYT4 ,                                                    !
001362 "TOTAL SUSPENDED SOLIDS      (PPM)           ",TSSMU
001364 PRINT
001366 IF (THMU > 1 OR CAMU > 1) THEN GOTO 1368   ELSE GOTO  1374
001368 IF (V1$="Y" OR V2$="Y" OR V3$="Y") THEN GOTO 1372   ELSE           !
001370 GOTO 1374
001372 PRINT WARNMU1$
001374 IF (MAMU > 50 OR MAMU < 10) THEN GOTO 1376   ELSE GOTO 1380
001376 IF V3$="Y" OR V4$="Y" OR V7$="Y" THEN GOTO 1378   ELSE GOTO 1380
001378 PRINT WARNMU2$
001380 IF TSSMU > 0 THEN GOTO 1382   ELSE GOTO 1390
001382 IF (V0$="Y" OR V1$="Y" OR V2$="Y") THEN GOTO 1388   ELSE           !
001384 GOTO 1386
001386 IF (V3$="Y" OR V4$="Y") THEN GOTO 1388   ELSE GOTO 1390
001388 PRINT WARNMU3$
001390 PRINT
001392 PRINT "*****     CONDENSATE RETURN QUALITY OF INTEREST     *****"
001394 PRINT
001396 PRINT USING LYT4 ,                                                    !
001398 "TOTAL HARDNESS              (PPM CACO3)     ",THCR
001400 PRINT USING LYT4 ,                                                    !
001402 "CALCIUM HARDNESS            (PPM CACO3)     ",CACR
001404 PRINT USING LYT4 ,                                                    !
001406 "MAGNESIUM HARDNESS          (PPM CACO3)     ",MGCR
001408 PRINT USING LYT4 ,                                                    !
001410 "M ALKALINITY                (PPM CACO3)     ",MACR
001412 PRINT USING LYT4 ,                                                    !
001414 "TOTAL DISSOLVED SOLIDS      (PPM)           ",TDSCR
001416 PRINT USING LYT4 ,                                                    !
001418 "SILICA                      (PPM SIO2)      ",SICR
001420 PRINT USING LYT4 ,                                                    !
001422 "TOTAL SUSPENDED SOLIDS      (PPM)           ",TSSCR
001424 PRINT USING LYT4 ,                                                    !
001426 "PH                                          ",PHCR
001428 PRINT USING LYT4 ,                                                    !
001430 "IRON                        (PPM FE)        ",FECR
001432 PRINT USING LYT4 ,                                                    !
001434 "COPPER                      (PPM CU)        ",CUCR
001436 IF (TDSCR > 10 OR SICR > 0 OR TSSCR > 10) THEN GOTO 1442  ELSE       !
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001438 GOTO 1440
001440 IF (THCR > 0 OR CACR > 0) THEN GOTO 1442   ELSE GOTO 1444
001442 PRINT WARNCR1$
001444 IF PHCR < 7.5 THEN GOTO 1446   ELSE GOTO 1448
001446 PRINT WARNCR2$
001448 IF PHCR > 8.0 THEN GOTO 1450   ELSE GOTO 1452
001450 PRINT WARNCR3$ : PRINT WARNCR4$
001452 IF FECR > .1 THEN GOTO 1454   ELSE GOTO 1456
001454 PRINT WARNCR5$
001456 IF CUCR > 0.01 THEN GOTO 1458   ELSE GOTO 1460
001458 PRINT WARNCR6$
001460 PRINT
001462 PRINT "*****     DEAERATING HEATER DATA     *****"
001464 PRINT
001466 PRINT USING LYT8 ,                                              !
001468 "OPERATING TEMPERATURE OF DEAERATING HEATER   (DEG F) = ",TF
001470 PRINT USING LYT8 ,                                              !
001472 "OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG) = ",PDA
001474 PRINT USING LYT8 ,                                              !
001476 "ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL        (FT)  = ",AMSL
001478 PRINT USING LYT11,                                              !
001480 "EFFLUENT OF YOUR 'DEAERATING HEATER'        (PPM O2) = ",OXF
001482 PRINT
001484 PRINT "*****     STEAM PRODUCTION DATA     *****"
001486 PRINT
001488 PRINT USING LYT7 ,                                              !
001490 "OPERATING GAUGE PRESSURE OF BOILER (PSIG)              =    ",PBLR
001492 PRINT USING LYT7 ,                                              !
001494 "RATED STEAM PRODUCTION OF BOILER (POUNDS/HOUR)         =     ",RS
001496 QSM = RS / FE
001498 PRINT USING LYT5 ,                                              !
001500 "MAXIMUM EVAPORATION (POUNDS/HOUR QSM)       =     ",QSM
001502 PRINT USING LYT5 ,                                              !
001504 "EVAPORATION CAPACITY INVESTIGATED (QS)      =     ",QS
001506 IF (QS > QSM OR QS > RS OR RS < QSM) THEN GOTO 1510   ELSE       !
001508 GOTO 1512
001510 PRINT WARNQS1$ : PRINT WARNQS2$
001512 PRINT
001514 PRINT "*****     DETERMINE OPERATING CONDITIONS     *****"
001516 PRINT
001518 PRINT USING LYT7 ,                                              !
001520 "ESTIMATED STEAM AND CONDENSATE LOSSES (POUNDS/HOUR QL)  =   ",QL
001522 PRINT "NOTE THAT A STRICT AFP 91-41 CALCULATION WOULD SET QL = 0"
001524 IF QL > (0.05 * QS) THEN GOTO 1526    ELSE GOTO 1528
001526 PRINT WARNQL1$ : PRINT WARNQL2$
001528 PRINT
001530 PRINT USING LYT7 ,                                              !
001532 "CONDENSATE RETURNED (POUNDS/HOUR QCR)                  =   ",QCR
001534 PRINT
001536 PRINT USING LYT5 ,                                              !
001538 "TOTAL DISSOLVED SOLIDS IN STEAM (PPM)       =     ",TDSS
001540 IF TDSS > 0 THEN GOTO 1542    ELSE GOTO 1544
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001542 PRINT WARNQS3$
001544 PRINT
001546 PRINT USING LYT5 ,                                                    !
001548 "MAKEUP (POUNDS/HOUR QMU) BASED ON TDS       =     ",QMUTDS
001550 PRINT
001552 PRINT USING LYT5 ,                                                    !
001554 "SILICA IN STEAM                             =     ",SIS
001556 IF SIS > 0 THEN GOTO 1558    ELSE GOTO 1560
001558 PRINT WARNQS3$
001560 PRINT
001562 PRINT USING LYT5 ,                                                    !
001564 "MAKEUP (POUNDS/HOUR QMU) BASED ON SIO2      =     ",QMUSI
001566 PRINT
001568 IF QMUTDS > QMUSI THEN GOTO 1582
001570 IF QMUSI > QMUTDS THEN GOTO 1590
001572 QMU = QMUTDS
001574 PRINT USING LYT6 ,                                                    !
001576 "MAKEUP EQUALLY CONSTRAINED BY TDS AND SIO2 (POUNDS/HOUR QMU)         !
001578  = ",QMU
001580 GOTO 1596
001582 QMU = QMUTDS
001584 PRINT USING LYT5 ,                                                    !
001586 "MAKEUP LIMITED BY TDS (POUNDS/HOUR QMU)     =     ",QMU
001588 GOTO 1596
001590 QMU = QMUSI
001592 PRINT USING LYT5 ,                                                    !
001594 "MAKEUP LIMITED BY SIO2 (POUNDS/HOUR QMU)    =     ",QMU
001596 PRINT
001598 PRINT "*****     FEEDWATER QUALITY     *****"
001600 PRINT
001602 PRINT USING LYT5 ,                                                    !
001604 "FEEDWATER (POUNDS/HOUR QF)                  =     ",QF
001606 PRINT USING LYT5 ,                                                    !
001608 "TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM)   =     ",TDSF
001610 PRINT "   BY CALCULATION"
001612 PRINT USING LYT5 ,                                                    !
001614 "TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM)   =     ",TDSFT
001616 PRINT "   BY TEST"
001618 PRINT WARNT1$ : PRINT
001620 PRINT USING LYT5 ,                                                    !
001622 "SILICA IN FEEDWATER          (PPM SIO2)     =     ",SIF
001624 PRINT "   BY CALCULATION"
001626 PRINT USING LYT5 ,                                                    !
001628 "SILICA IN FEEDWATER          (PPM SIO2)     =     ",SIFT
001630 PRINT "   BY TEST"
001632 PRINT WARNT1$
001634 PRINT
001636 PRINT "*****     CYCLES OF CONCENTRATION     *****"
001638 PRINT
001640 PRINT USING LYT5 ,                                                    !
001642 "OPERATIONAL LIMIT SET FOR TDS    (PPM)      =     ",TDSBD
001644 PRINT USING LYT5 ,                                                    !
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001646 "OPERATIONAL LIMIT SET FOR SILICA (PPM SIO2) =     ",SIBD
001648 PRINT
001650 PRINT USING LYT5 ,                                                    !
001652 "CYCLES BASED ON TDS - DESIGN LIMIT          =     ",CYCTDSD
001654 IF SIF = 0 THEN GOTO 1656  ELSE GOTO 1658
001656 PRINT "     BOILER IS NOT SILICA LIMITED!" : GOTO 1662
001658 PRINT USING LYT5 ,                                                    !
001660 "CYCLES BASED ON SILICA - DESIGN LIMIT       =     ",CYCSID
001662 PRINT USING LYT5 ,                                                    !
001664 "OPERATING CYCLES OF CONCENTRATION           =     ",CYC
001666 PRINT : PRINT USING LYT5 ,                                            !
001668 "CALCULATED OPERATING BOILER TDS     (PPM)       = ",BLRTDS
001670 PRINT WARNT1$ : PRINT
001672 PRINT USING LYT5 ,                                                    !
001674 "CALCULATED OPERATING BOILER SILICA  (PPM SIO2)  = ",BLRSI
001676 PRINT WARNT1$
001678 PRINT
001680 PRINT "*****     DETERMINE BLOWDOWN     *****"
001682 PRINT
001684 PRINT USING LYT5 ,                                                    !
001686 "BLOWDOWN (POUNDS/HOUR  QBD)                 =     ",QBD
001688 PRINT WARNQ1$
001690 PRINT
001692 PRINT "*****     DETERMINE PHOSPHATE DOSAGE PER DAY     *****"
001694 PRINT
001696 PRINT "PHOSPHATE CHEMICAL USED  ",PHS$
001698 PRINT USING LYT8 ,                                                    !
001700 "PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL      =     ",PHSPC
001702 PRINT "POUNDS OF PHOSPHATE CHEMICAL REQUIRED TO TREAT 1,000 GALLO!
001704 NS OF FEEDWATER PER   "
001706 PRINT USING LYT3 ,                                                    !
001708 "PPM HARDNESS  =     ",PHSNHD
001710 PRINT "POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS !
001712 OF PHOSPHATE CHEMICAL "
001714 PRINT USING LYT3 ,                                                    !
001716 "               =     ",PHSNOH
001718 PRINT
001720 PRINT USING LYT5 ,                                                    !
001722 "RESIDUAL PO4 DESIRED IN BOILER    (PPM PO4)      =",PHSBD
001724 PRINT USING LYT5 ,                                                    !
001726 "POUNDS OF PHOSPHATE CHEMICAL/DAY FOR RESIDUAL    =",PHSWR
001728 PRINT USING LYT5 ,                                                    !
001730 "POUNDS OF PHOSPHATE CHEMICAL/DAY FOR HARDNESS    =",PHSWHD
001732 PRINT USING LYT5 ,                                                    !
001734 "TOTAL POUNDS OF PHOSPHATE CHEMICAL/DAY AFP 91-41 =",PHSW
001736 PRINT
001738 PRINT "*****     DETERMINE CAUSTIC SODA DOSAGE PER DAY     *****"
001740 PRINT
001742 PRINT USING LYT5 ,                                                    !
001744 "PURITY (%) OF CAUSTIC SODA USED             =     ",NAOHPC
001746 PRINT USING LYT5 ,                                                    !
001748 "POUNDS/DAY FOR PHOSPHATE HYDROLYSIS AFP 91-41  =  ",NAOHWPH
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001750 PRINT
001752 PRINT USING LYT5 ,                                                    !
001754 "CALCULATED SILICA IN FEEDWATER                =     ",SIF
001756 PRINT USING LYT5 ,                                                    !
001758 "SILICA IN FEEDWATER BY TEST                   =     ",SIFT
001760 PRINT WARNT1$ : PRINT
001762 PRINT USING LYT5 ,                                                    !
001764 "SILICA NEEDED FOR MAGNESIUM REACTIONS         =     ",SINHD
001766 PRINT
001768 IF SIF > SINHD THEN GOTO 1770   ELSE GOTO 1772
001770 PRINT WARNF1$ : GOTO 1774
001772 PRINT WARNF2$
001774 PRINT
001776 IF PHSW = 0 THEN GOTO 1786
001778 IF BLRSI >= 0.5 *(PHSW * PHSPC * 997504.12)/(QBD * 24 * 100) THEN!
001780 GOTO 1782   ELSE GOTO 1784
001782 PRINT WARNF3$ : GOTO 1786
001784 PRINT WARNF4$ : PRINT WARNF5$
001786 PRINT
001788 PRINT USING LYT4 ,                                                    !
001790 "TOTAL CAUSTIC SODA POUNDS/DAY           =     ",NAOHW
001792 PRINT
001794 PRINT "*****     DETERMINE LIGNOSULFONATE DOSAGE PER DAY    *****"
001796 PRINT
001798 PRINT USING LYT4 ,                                                    !
001800 "RESIDUAL PPM LIGNOSULFONATE DESIRED    =     ",LSNBD
001802 PRINT USING LYT4 ,                                                    !
001804 "PURITY (%) OF LIGNOSULFONATE CHEMICAL  =     ",LSNPC
001806 PRINT USING LYT4 ,                                                    :
001808 "LIGNOSULFONATE DOSAGE FOR RESIDUAL     =     ",LSNWR
001810 PRINT USING LYT8 ,                                                    !
001812 "LIGNOSULFONATE DOSAGE FOR FDWTR 20 % M ALKALINITY  =   ",LSNWMAF
001814 PRINT USING LYT8 ,                                                    !
001816 "LIGNOSULFONATE DOSAGE REQUIRED (POUNDS/DAY)        =   ",LSNW
001818 PRINT
001820 PRINT "*****     DETERMINE SULFITE DOSAGE PER DAY     *****"
001822 PRINT
001824 GOSUB DAOPS
001826 PRINT USING LYT4 ,                                                    !
001828 "RESIDUAL SULFITE (PPM SO3) DESIRED     =     ",SFBD
001830 PRINT USING LYT4 ,                                                    !
001832 "PURITY (%) OF SULFITE CHEMICAL         =     ",SFPC
001834 PRINT USING LYT4 ,                                                    !
001836 "SODIUM SULFITE NEEDED FOR RESIDUAL     =     ",SFWR
001838 PRINT USING LYT4 ,                                                    !
001840 "SODIUM SULFITE REQUIRED (POUNDS/DAY)   =     ",SFW
001842 PRINT
001844 PRINT "*****     DETERMINE NEUTRALIZING AMINE DOSAGE     *****"
001846 PRINT "*****           FOR A 50/50 MIXTURE OF            *****"
001848 PRINT "*****        CYCLOHEXYLAMINE AND MORPHOLINE       *****"
001850 PRINT
001852 PRINT USING LYT4 ,                                                    !
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001854 "P ALKALINITY IN FEEDWATER BY TEST      =     ",PAFT
001856 PRINT USING LYT4 ,                                                    !
001858 "CALCULATED M ALKALINITY IN FEEDWATER   =     ",MAF
001860 PRINT USING LYT4 ,                                                    !
001862 "M ALKALINITY IN FEEDWATER BY TEST      =     ",MAFT
001864 PRINT WARNT1$ : PRINT
001866 PRINT USING LYT4 ,                                                    !
001868 "PER CENT OF CARBONATE ALKALINITY BREAKDOWN = ",CARBPC
001870 PRINT USING LYT4 ,                                                    !
001872 "CALCULATED FEEDWATER BICARBONATE ALKALINITY =",BICARBF
001874 PRINT USING LYT4 ,                                                    !
001876 "CALCULATED FEEDWATER CARBONATE ALKALINITY   =",CARBF
001878 IF PHSW = 0 AND CAF > (0.5*BICARBF*1.22/61+CARBF*0.6/60)*40.1/.4*!
001880 (100-CARBPC)/100 THEN GOTO 1882    ELSE GOTO 1884
001882 PRINT WARNPHS1$ : PRINT WARNPHS2$ : PRINT
001884 PRINT USING LYT4 ,                                                    !
001886 "EQUIV CARBON DIOXIDE (PPM CO2) IN FEEDWATER = ",CDOF
001888 PRINT
001890 PRINT USING LYT4 ,                                                    !
001892 "PURITY (%) OF CYCLOHEXYLAMINE USED     =     ",CHAPC
001894 PRINT USING LYT4 ,                                                    !
001896 "PURITY (%) OF MORPHOLINE USED          =     ",MORPC
001898 PRINT USING LYT4 ,                                                    !
001900 "CYCLOHEXYLAMINE DOSAGE (LB/DAY) (50/50 MIX) =",CHAW
001902 PRINT USING LYT4 ,                                                    !
001904 "MORPHOLINE DOSAGE      (LB/DAY) (50/50 MIX) =",MORW
001906 PRINT WARNNA1$ : PRINT WARNNA2$ : PRINT
001908 PRINT WARNNA3$ : PRINT WARNNA4$ : PRINT
001910 PRINT WARNNA5$ :PRINT WARNNA6$ : PRINT : PRINT
001912 PRINT "THESE CHEMICAL DOSAGES WILL NOW AFFECT THE TOTAL DISSOLVED!
001914  SOLIDS AND OTHER"
001916 PRINT "CONSTITUENT LEVELS IN THE BOILER AND THUS AFFECT THE CYCLE!
001918 S OF CONCENTRATION."  : PRINT
001920 PRINT "RUN THE ADVANCED ANALYSIS CALCULATIONS TO RECEIVE A BETTER!
001922  ESTIMATE OF THE DAILY"
001924 PRINT "DOSAGES AT THE FINAL SYSTEM EQUILIBRIUM POINT FOR COMPARIS!
001926 ON WITH THE           "
001928 PRINT "ACTUAL DOSAGES PROVIDED TO THE BOILER."
001930 CLOSE PRINTER : SELECT WS : GOTO EXIT1
```

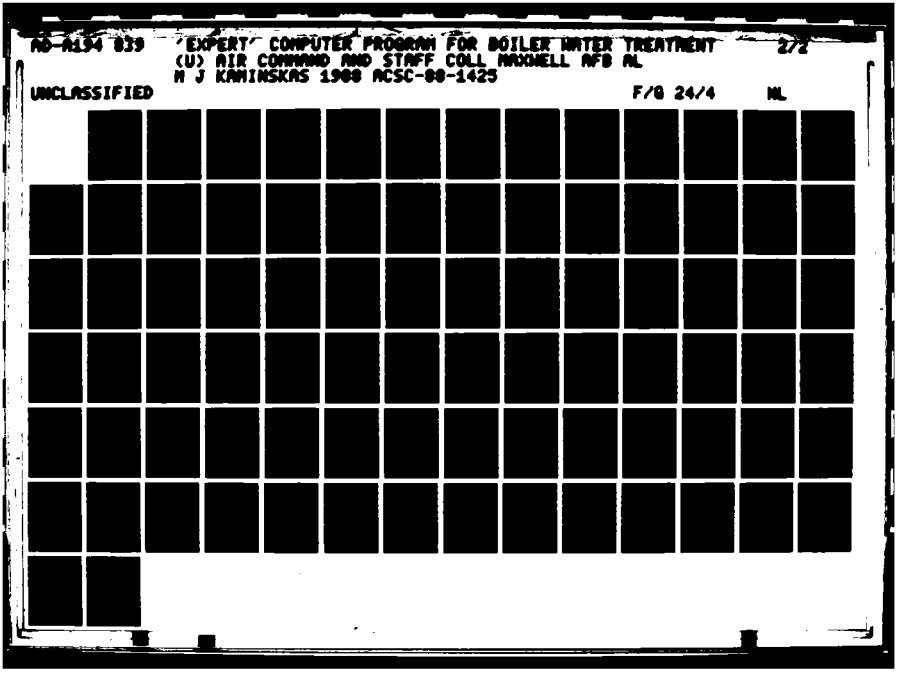
Appendix Three

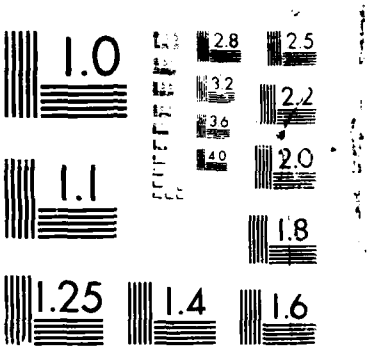
CALL SUBROUTINE FOR ADVANCED CALCULATIONS
AND TREATMENT ANALYSIS

```
000010 SUB "CALCS"
000012 * THIS SUBPROGRAM CALCULATES THE MASSFLOW QUANTITIES AND CHEMICAL
000014 *   DOSAGES FOR STEAM BOILER WATER TREATMENT USING RATED BOILER
000016 *   QUANTITIES ADJUSTED FOR ACTUAL OPERATING CONDITIONS, QUALITY
000018 *   OF AVAILABLE MAKEUP, AND QUALITY OF CONDENSATE RETURNED.
000020 *
000022 *   THIS PROGRAM GOES BEYOND AFP 91-41, INDUSTRIAL WATER TREATMENT
000024 *   PROCEDURES, (18 SEPTEMBER 1987) AND ESTIMATES THE FINAL
000026 *   OPERATING POINT OF THE BOILER TAKING INTO ACCOUNT ALL CHEMICAL
000028 *   EFFECTS AND COMPARES RESULTS TO ACTUAL OPERATIONAL TESTING AND
000030 *   CHEMICAL DOSAGES.
000032 *
000034 * THE MAIN PROGRAM CREATES AND MAINTAINS THE DATA FILE THAT THIS
000036 *   SUBPROGRAM ACCESSES
000038 *
000040 * A DESCRIPTION OF VARIABLES IS AVAILABLE AT THE BEGINNING OF THE
000042 *   THE MAIN PROGRAM
000044 *
000046 ***   INITIALIZE VARIABLES TO ZERO AND SET GENERAL INFO
000048 * THE WANG VS 100 COMPUTER AUTOMATICALLY INITIALIZES ALL
000050 *     VARIABLES TO ZERO
000052 LYT3 : FMT CH(20),       PIC(##0.####)
000054 LYT4 : FMT CH(45),     PIC(#,##0.##)
000056 LYT5 : FMT CH(50), PIC(#,###,##0.##)
000058 LYT7 : FMT CH(60), PIC(#,###,##0.##)
000060 LYT8 : FMT CH(55),     PIC(#,##0.##)
000062 LYT9 : FMT CH(40), CH(40)
000064 LYT10 : FMT CH(30), CH(45)
000066 LYT11 : FMT CH(55),      PIC(##0.####)
000068 LYT12 : FMT CH(50),    PIC(#,##0.########)
000070 *
000072 COM AMSL,HG,PAB,PATM,PBLR,UID$ 3,IPLVOL$ 6,DEEDATAVOL$ 6
000074 DIM DATE$ 6,BASEID$ 3,BLDG$ 7,BLR$ 2,RID$ 2,                    !
000076 BASE$ 20,OPR$ 15,PHS$ 40,                                       !
000078 OTHAM$ 40,OTHLSN$ 40,OTHOH$ 40,OTHPHS$ 40,OTHSF$ 40,            !
000080 WARNC1$ 80,WARNBD1$ 80,WARNBD2$ 80,WARNBD3$ 80,                 !
000082 WARNDA1$ 80,WARNDA2$ 80,WARNDA3$ 80,                            !
000084 WARNF1$ 80,WARNF2$ 80,WARNF3$ 80,WARNF4$ 80,                    !
```

AD-A194 039 'EXPERT' COMPUTER PROGRAM FOR BOILER WATER TREATMENT (U) AIR COMMAND AND STAFF COLL MAXWELL AFB AL M J KAMINSKAS 1988 ACSC-88-1425 2/2

UNCLASSIFIED F/G 24/4 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963

```
000086 WARNLSN1$ 80,WARNLSN2$ 80,                                              !
000088 WARNMA1$ 80,WARNMA2$ 80,WARNMA3$ 80,                                    !
000090 WARNNA1$ 80,WARNNA2$ 80,WARNNA3$ 80,WARNNA4$ 80,                        !
000092 WARNOH1$ 80,WARNOH2$ 80,WARNOH3$ 80,WARNOH4$ 80,WARNOH5$ 80,            !
000094 WARNOH6$ 80,WARNOH7$ 80,WARNOH8$ 80,WARNOH9$ 80,                        !
000096 WARNPHS1$ 80,WARNPHS2$ 80,WARNQMU1$ 80,                                 !
000098 WARNSI1$ 80,WARNSF1$ 80,WARNSF2$ 80,                                    !
000100 WARNTDS1$ 80,WARNTDS2$ 80,WARNTDS3$ 80,WARNTDS4$ 80,WARNTDS5$ 80,       !
000102 WARNTSS1$ 80,WARNTSS2$ 80,WARNTSS3$ 80,                                 !
000104 CHEMCYC(100),DSIMU(100),DTDSMU(100),DTSSMU(100),                        !
000106 SFWOX(100),SFWR(100),COMMENT$ 45
000108 *
000110 WARNBD1$ ="DANGER -INSUFFICIENT EXISTING HYDROXYL ALKALINITY TO F!
000112 ORM HYDROXYAPATITE OR"
000114 WARNBD2$ ="SERPENTINE!  CHEMICAL REACTIONS THIS PROGRAM IS BASED !
000116 UPON WILL NOT OCCUR!"
000118 WARNBD3$ ="CHECK BOILER PH AND HYDROXYL ALKALINITY TESTING-RESULT!
000120 S ARE INCONSISTENT."
000122 WARNC1$ ="THE ONLY CHEMICAL EFFECT ON FEEDWATER QUALITY IS THE SU!
000124 LFITE ADDED AT DEAERATOR."
000126 WARNDA1$ ="THE DEAERATING HEATER IS NOT BOILING PROPERLY!  CHECK !
000128 CALIBRATION OF THE"
000130 WARNDA2$ ="  GAUGES AND TEST THE OXYGEN CONTENT OF THE FEEDWATER.!
000132 "
000134 WARNDA3$ ="THE DEAERATING HEATER PRESSURE AND TEMPERATURE INDICAT!
000136 E PROPER OPERATION."
000138 WARNF1$ ="SUFFICIENT SILICA FOR MAGNESIUM REACTION TO FORM SERPEN!
000140 TINE."
000142 WARNF2$ ="WARNING-INSUFFICIENT SILICA AVAILABLE FOR MAGNESIUM REA!
000144 CTION TO FORM SERPENTINE!"
000146 WARNF3$ ="WARNING-INSUFFICIENT HYDROXYL ALKALINITY AVAILABLE TO F!
000148 ORM MAGNESIUM HYDROXIDE!"
000150 WARNF4$ ="WARNING-RESULT IS FORMATION OF UNDESIRABLE BASIC MAGNE!
000152 SIUM PHOSPHATE!"
000154 WARNLSN1$ ="LIGNOSULFONATE IS ABOVE RANGE - WASTE OF CHEMICAL!"
000156 WARNLSN2$ ="LIGNOSULFONATE OPERATING LEVEL IS LOW - MAY RESULT IN!
000158  BAKED-ON SLUDGE!"
000160 WARNMA1$ ="WARNING-CALCULATED BOILER M ALKALINITY EXCEEDS 20% OF !
000162 BOILER TDS.  THIS CAUSES"
000164 WARNMA2$ ="DETRIMENTAL FOAMING.  SPLIT-STREAM SOFTEN, DEALKALIZE,!
000166 OR USE SODIUM BISULFITE"
000168 WARNMA3$ ="TO REDUCE ALKALINITY."
000170 WARNNA1$ ="NOTE THE MIXTURE RATIOS AND MAXIMUM DOSAGES ALLOWED FO!
000172 R NEUTRALIZING AMINES"
000174 WARNNA2$ ="  PER AFP 91-41."
000176 WARNNA3$ ="DO NOT USE AMINES IF STEAM COMES INTO DIRECT CONTACT W!
000178 ITH FOOD.  IMMEDIATELY  "
000180 WARNNA4$ ="HAVE SERVICES PROGRAM EQUIPMENT REPLACEMENT AS THIS IS!
000182  AGAINST STATED POLICY."
000184 WARNOH1$ ="EXCESS HYDROXYL ALKALINITY TO MEET RESIDUAL NEEDS."
000186 WARNOH2$ ="IF OH ALKALINITY IN BOILER EXCEEDS 500 PPM (AS CACO3) !
000188 THEN INVESTIGATE USE OF"
```

```
000190 WARNOH3$ ="  DEALKALIZATION, ACIDIC TREATMENT CHEMICALS, OR REDUC!
000192 E CAUSTIC FOR HYDROLYSIS."
000194 WARNOH4$ ="HYDROXYL ALKALINITY OR BOILER PH ABOVE RANGE - EXPECT !
000196 CAUSTIC ATTACK!"
000198 WARNOH5$ ="HYDROXYL ALKALINITY OR BOILER PH IS LOW - EXPECT CORRO!
000200 SION AND BAD REACTIONS!"
000202 WARNOH6$ ="  ESTIMATED HYDROXYL ALKALINITY IN BOILER IS HEAVILY D!
000204 EPENDENT ON PERCENT"
000206 WARNOH7$ ="  CARBONATE ALKALINITY SELECTED, USE OF NEUTRALIZING A!
000208 MINES, AND REACTIONS NOT"
000210 WARNOH8$ ="  TAKEN INTO ACCOUNT.  ACTUAL VALUES MEASURED MAY BE A!
000212 S LITTLE AS 20 PERCENT OF"
000214 WARNOH9$ ="  THE ABOVE ESTIMATE."
000216 WARNPHS1$ ="WARNING-WITH NO PHOSPHATE ADDED, THERE IS ALSO NOT EN!
000218 OUGH CARBONATE ALKALINITY"
000220 WARNPHS2$ ="TO PREVENT CALCIUM SULFATE SCALE!  SOFTEN THE MAKEUP !
000222 OR ADD SODA ASH (NA2CO3)!"
000224 WARNPHS3$ ="PHOSPHATE ABOVE RANGE - WASTE OF CHEMICAL!"
000226 WARNPHS4$ ="PHOSPHATE IS LOW - MAY CAUSE SCALE!"
000228 WARNQMU1$ ="COMPARE THIS CALCULATED MAKEUP FLOW TO THE METERED VA!
000230 LUE."
000232 WARNSI1$ ="SILICA ABOVE RANGE - EXPECT DAMAGING SCALE IN BOILER A!
000234 ND CARRYOVER IN STEAM!"
000236 WARNSF1$ ="SULFITE ABOVE RANGE - WASTE OF CHEMICAL!"
000238 WARNSF2$ ="SULFITE OPERATING LEVEL IS LOW - MAY RESULT IN OXYGEN !
000240 CORROSION!"
000242 WARNTDS1$ ="TDS ABOVE RANGE - EXPECT SCALING AND FOAMING!"
000244 WARNTDS2$ ="TDS OPERATING LEVEL IS LOW - WASTE OF ENERGY AND CHEM!
000246 ICALS!"
000248 WARNTDS3$ ="TDS ABOVE EXPECTED RANGE - MAY CAUSE DAMAGING SILICA !
000250 SCALE!"
000252 WARNTDS4$ ="TDS BELOW EXPECTED RANGE - WASTE OF ENERGY AND CHEMIC!
000254 ALS!"
000256 WARNTDS5$ ="TDS ABOVE EXPECTED RANGE - MAY CAUSE DAMAGING BAKED-O!
000258 N SLUDGE OR SILICA SCALE!"
000260 WARNTSS1$ ="WARNING-CALCULATIONS PREDICT EXCESSIVE SUSPENDED SOLI!
000262 DS IN BOILER.  INVESTIGATE"
000264 WARNTSS2$ ="HARD MAKEUP WITH NO PHOSPHATE, SOFTENING AND PHOSPHAT!
000266 E, AND ELIMINATION OF"
000268 WARNTSS3$ ="CONDENSATE RETURN HARDNESS CONTAMINATION!"
000270 *
000272 * ACCESS EXISTING FILE FOR DATA TO USE IN THESE CALCULATIONS
000274 SELECT #1,"ESTM",INDEXED,RECSIZE=826,KEYPOS = 1, KEYLEN = 23
000276 SELECT PAUSE 10 : REM A 1 SECOND PAUSE AFTER EACH PRINT STATEMENT!
000278                       WITHOUT A LITERAL STRING ATTACHED
000280 N = 1 : ACCEPT                                                  !
000282 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                 !
000284 AT(3,1), "INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAM!
000286 E (KEYFIELD) OF THE DATA",                                      !
000288 AT(4,3), "RECORD YOU ARE INTERESTED IN.  YOU WILL THEN HAVE TO ST!
000290 EP THROUGH THE RECORDS",                                        !
000292 AT(5,3), "UNTIL YOU FIND THE ONE YOU WANT.",                     !
```

```
000294 AT(7,10),"COMPUTER USER ID  = ",UID$,CH(3),                          !
000296 AT(12,1),"NOTE - THE CALCULATIONS ARE BASED ON INITIAL MAKEUP AND!
000298  CONDENSATE QUALITIES,",                                            !
000300 AT(13,3),"AS WELL AS SYSTEM OPERATION.  ADJUST RECORD VALUES TO A!
000302 DJUST THE INPUT VALUES",                                            !
000304 AT(14,3),"TO THE CALCULATIONS.",                                    !
000306 AT(16,3),"A DECISION FOR ONE PRINTOUT IS AVAILABLE AT THE END OF !
000308 THE RUN.",                                                          !
000310 AT(20,1),  "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0)) : PRINT
000312 OPEN NODISPLAY #1, SHARED,FILE="ESTM",LIBRARY="EIXXDATA",           !
000314 VOLUME=DEEDATAVOL$,SPACE=100
000316 LYT2 : FMT CH(3),CH(6),CH(3),CH(7),CH(2),CH(2),                     !
000318 PIC(#####),CH(20),                                                  !
000320 4*PIC(####.##),                                                     !
000322 2*PIC(####.##),                                                     !
000324 6*PIC(####.##),                                                     !
000326 2*PIC(####.##),CH(15),PIC(###.####),                                !
000328 6*PIC(####.##),POS(220),PIC(###.####),CH(40),                       !
000330 3*PIC(#######.##),7*PIC(####.##),                                   !
000332 8*PIC(####.##),POS(454),                                            !
000334 4*PIC(####.##),                                                     !
000336 4*PIC(####.##),                                                     !
000338 6*PIC(####.##),                                                     !
000340 5*PIC(###.##),                                                      !
000342 5*CH(40),CH(45)
000344 *
000346 IF N = 1 THEN GOTO 348   ELSE GOTO START1
000348 READ #1, HOLD, KEY = UID$, EOD GOTO EXIT1  : GOTO 352
000350 START1 : READ #1, HOLD, EOD GOTO EXIT1
000352 N = N + 1
000354 GET #1 USING LYT2 , UID$,DATE$,BASEID$,BLDG$,BLR$,RID$,             !
000356 AMSL,BASE$,                                                         !
000358 CACR,CAMU,CARBPC,CHAPC,                                             !
000360 LSNBD,LSNPC,                                                        !
000362 MACR,MAFT,MAMU,MGCR,MGMU,MORPC,                                     !
000364 NAOHPC,OHBDT,OPR$,OXF,                                              !
000366 PAFT,PBLR,PDA,PHBLR,PHSBD,PHSPC,PHSNOH,PHS$,                        !
000368 QL,QS,RS,SIBD,SICR,SIFT,SIMU,SIS,SFBD,SFPC,                         !
000370 TDSBD,TDSCR,TDSFT,TDSMU,TDSS,TF,TSSCR,TSSMU,                        !
000372 CAFT,CHADR,MORDR,OHBD,                                              !
000374 LSNBDT,PHSBDT,SFBDT,TDSBDT,                                         !
000376 LBCHA,LBLSN,LBMOR,LBOH,LBPHS,LBSF,                                  !
000378 LBOTHAM,LBOTHLSN,LBOTHOH,LBOTHPHS,LBOTHSF,                          !
000380 OTHAM$,OTHLSN$,OTHOH$,OTHPHS$,OTHSF$,COMMENT$
000382 *
000384 START2 : Y$ = "QQ" : ACCEPT                                         !
000386 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                     !
000388 AT(3,1), "THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE !
000390 DATA RECORD OBSERVED.",                                             !
000392 AT(5,1), "SELECT ACTION FOR RECORD OF INTEREST LISTED BELOW!",      !
000394 AT(6,5), "INPUT ACTION SELECTION ",FAC(HEX(91)),Y$,CH(1),           !
000396 AT(7,2), "(S) = SELECT THIS RECORD",                                !
```

```
000398 AT(8,2), "(N) = GO TO NEXT RECORD",                                    !
000400 AT(9,2), "(E) = NO ACTION, EXIT TO PREVIOUS MENU",                     !
000402 AT(11,9),"RECORD OF INTEREST",                                         !
000404 AT(12,9),"COMPUTER USER ID     ",FAC(HEX(8D)),UID$,CH(3),               !
000406 AT(13,9),"TODAY'S DATE         ",FAC(HEX(8D)),DATE$,CH(6),              !
000408 AT(14,9),"BASE ID              ",FAC(HEX(8D)),BASEID$,CH(3),            !
000410 AT(15,9),"BUILDING NUMBER      ",FAC(HEX(8D)),BLDG$,CH(7),              !
000412 AT(16,9),"BOILER DESIGNATOR    ",FAC(HEX(8D)),BLR$,CH(2),               !
000414 AT(17,9),"RUN INDICATOR        ",FAC(HEX(8D)),RID$,CH(2),               !
000416 AT(18,1),"COMMENT DESCRIBING THIS DATA ",FAC(HEX(8D)),COMMENT$,         !
000418 CH(45),                                                                !
000420 AT(20,5), "IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE!
000422  USER ID REQUEST.",                                                    !
000424 AT(22,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0))
000426 IF Y$ = "E" THEN GOTO EXIT1
000428 IF Y$ = "N" THEN GOTO START1
000430 IF Y$ = "S" THEN GOTO NEXT1  ELSE GOTO START2
000432 NEXT1 : IF (PHBLR < 11 AND OHBDT < 50) THEN GOTO 436    ELSE          !
000434 GOTO 438
000436 PRINT WARNBD1$ : PRINT WARNBD2$
000438 IF (PHBLR < 11.0 AND OHBDT > 50) OR (PHBLR > 11.0 AND OHBDT < 50)!
000440 THEN GOTO 442    ELSE GOTO 444
000442 PRINT WARNBD3$
000444 PRINT : PRINT
000446 START3 : Z$ = "QQ" : ACCEPT                                            !
000448 AT(1,20),"STEAM BOILER WATER TREATMENT PROGRAM",                        !
000450 AT(3,1), "THE ONLY CALCULATED QUANTITY THAT CAN BE CONSTRAINED IS!
000452  MAKEUP FLOW.  THIS IS ",                                              !
000454 AT(4,3), "ADVANTAGEOUS WHEN COMPARING RESULTS TO AN ACTUAL OPERAT!
000456 ING SYSTEM.  MAKEUP ",                                                 !
000458 AT(5,3), "IS USUALLY THE MOST ACCURATE METERED QUANTITY AVAILABLE!
000460 .",                                                                    !
000462 AT(7,1), "DO YOU WISH TO CONSTRAIN MAKEUP FLOW ( Y OR N ) ?",           !
000464 FAC(HEX(91)),Z$,CH(1),                                                 !
000466 AT(9,1), "IF MAKEUP IS CONSTRAINED, WHAT QUANTITY IN POUNDS/HOUR !
000468 DO YOU WANT TO ",                                                      !
000470 AT(10,3),"INVESTIGATE?",QMUC,PIC(#######.##),                          !
000472 AT(15,1), "PRESS <ENTER> TO CONTINUE", KEYS(BIN(0)) : PRINT
000474 IF (Z$ <> "Y") AND (Z$ <> "N") THEN GOTO START3
000476 IF (Z$ = "Y") AND (QMUC <= 0) THEN GOTO 478    ELSE GOTO 482
000478 PRINT "CONSTRAINED MAKEUP MUST BE GREATER THAN ZERO!" : PRINT :  !
000480 PRINT : PRINT : GOTO START3
000482 ***   DETERMINE ACTUAL MASSFLOWS
000484 *
000486 CALL "ENTHALPY"
000488 FE = (HG - (TF-32))/970.3
000490 QSM = RS/FE
000492 QCR = QS - QL
000494 PRINT USING LYT5 ,                                                     !
000496 "RATED EVAPORATION (POUNDS/HOUR)              =     ",RS
000498 PRINT USING LYT5 ,                                                     !
000500 "MAXIMUM EVAPORATION (POUNDS/HOUR QS)         =     ",QSM
```

```
000502 PRINT USING LYT7 ,                                                    !
000504 "ACTUAL EVAPORATION TO BE INVESTIGATED (POUNDS/HOUR)     =  ",QS
000506 PRINT
000508 PRINT USING LYT7 ,                                                    !
000510 "ESTIMATED STEAM AND CONDENSATE LOSSES (POUNDS/HOUR QL)  =  ",QL
000512 PRINT
000514 PRINT USING LYT5 ,                                                    !
000516 "CONDENSATE RETURNED (POUNDS/HOUR QCR)       =     ",QCR
000518 PRINT : N = 1
000520 *  THE ITERAUTO SECTION PROVIDES AUTOMATIC ITERATION TO FIND THE
000522 *    OPERATING POINT OF THE BOILER.
000524 ITERAUTO :
000526 M = N - 1
000528 QMUTDS = (TDSCR*QCR-TDSS*QS+TDSBD*QL)/(TDSBD-TDSMU-DTDSMU(M))
000530 QMUSI = (SICR*QCR-SIS*QS+SIBD*QL)/(SIBD-SIMU-DSIMU(M))
000532 * FOLLOWING DECISION PREVENT DIVISION BY ZERO
000534 IF N = 1 THEN GOTO 536     ELSE GOTO 538
000536 QMUTSS = 1 : GOTO 546
000538 QMUTSS = (TSSCR*QCR+0.08*BLRTDS*QL)/(0.08*BLRTDS-TSSMU-DTSSMU(M))
000540 *  FOLLOWING DECISION ALLOWS CALCULATION OF DXXXX QUANTITIES UNDER
000542 *    CONSTRAINED MAKEUP TO MORE CLOSELY PREDICT DESIGN AND ACTUAL
000544 *    CYCLES BASED ON TDS, SILICA, AND TSS
000546 IF Z$ = "Y" THEN GOTO 548     ELSE GOTO 550
000548 QMU = QMUC : GOTO 558
000550 IF QMUTDS >= QMUSI THEN GOTO 554
000552 IF QMUSI > QMUTDS THEN GOTO 556
000554 QMU = QMUTDS : GOTO 558
000556 QMU = QMUSI
000558 QF = QCR + QMU
000560 QBD = QMU - QL
000562 CYC = QF/QBD
000564 CHEMCYC(N) = CYC
000566 TDSF1 = (TDSCR*QCR+TDSMU*QMU)/QF
000568 TDSF2 = SFWR(M)*997504.12/(24*QF)
000570 TDSF3 = SFWOX(M)*SFPC*142.0*997504.12/(100*126.1*24*QF)
000572 TDSF4 = SFWOX(M)*(100-SFPC)*997504.12/(100*24*QF)
000574 TDSF = TDSF1 + TDSF2 + TDSF3 + TDSF4
000576 TDSFE = (TDSCR*QCR+(TDSMU+DTDSMU(M))*QMU)/QF +TDSF2+TDSF3+TDSF4
000578 SIF = (SICR*QCR+SIMU*QMU)/QF
000580 SIFE = (SICR*QCR+(SIMU+DSIMU(M))*QMU)/QF
000582 TSSF = (TSSCR*QCR+TSSMU*QMU)/QF
000584 TSSFE = (TSSCR*QCR+(TSSMU+DTSSMU(M))*QMU)/QF
000586 CYCTDSD = TDSBD/TDSFE : BLRTDS = TDSFE*CYC : CYCTDSA = BLRTDS/TDSF
000588 **  THE FOLLOWING SETS CYCLES TO A VERY LARGE NUMBER IF NO SILICA
000590 **  IS PRESENT IN THE FEEDWATER
000592 IF SIFE <= 0 THEN GOTO 594     ELSE GOTO 596
000594 CYCSID = 1000000 : BLRSI = 0 : GOTO 598
000596 CYCSID = SIBD / SIFE : BLRSI = SIFE * CYC
000598 IF SIF = 0 THEN GOTO 600     ELSE GOTO 602
000600 CYCSIA = 1000000 : GOTO 608
000602 CYCSIA = BLRSI / SIF
000604 **  THE FOLLOWING SETS CYCLES TO A VERY LARGE NUMBER IF
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000606 **  NO SUSPENDED SOLIDS ARE PRESENT IN THE FEEDWATER
000608 IF TSSFE <= 0 THEN GOTO 610     ELSE GOTO 612
000610 CYCTSSD = 1000000 : BLRTSS = 0 : GOTO 614
000612 CYCTSSD = 0.08 * TDSBD / TSSFE : BLRTSS = TSSFE * CYC
000614 IF TSSF = 0 THEN GOTO 616     ELSE GOTO 618
000616 CYCTSSA = 1000000 : GOTO 620
000618 CYCTSSA = BLRTSS / TSSF
000620 CAF = (CAMU * QMU + CACR * QCR) / QF
000622 IF PHSBD = 0 THEN GOTO 624     ELSE GOTO 626
000624 PHSWR = 0 : PHSWCAF = 0 : GOTO 630
000626 PHSWR = (QBD*24*PHSBD*100)/(PHSPC*997504.12)
000628 PHSWCAF = 24*QF*(CAF*0.6*0.4*95*100)/(40.1*PHSPC*997504.12)
000630 PHSW = PHSWR + PHSWCAF
000632 MGF = (MGMU * QMU + MGCR * QCR) / QF
000634 IF MGF = 0 THEN GOTO 636     ELSE GOTO 638
000636 NAOHWMGF1 = 0: NAOHWMGF2 = 0: SINHD = 0: DMGF = 0: GOTO 664
000638 IF SIF = 0 THEN GOTO 640     ELSE GOTO 644
000640 NAOHWMGF1 = 24*QF*(MGF*0.24*2*40*100)/(24.3*NAOHPC*997504.12)
000642 NAOHWMGF2 = 0 :  SINHD = 0 : DMGF = 0 : GOTO 664
000644 SINHD = (MGF*0.24*2/3*60.1/24.3) + 0.5*(PHSWR*997504.12*PHSPC)/  !
000646 (100*24*QF)
000648 IF SIF >= SINHD THEN GOTO 650     ELSE GOTO 656
000650 NAOHWMGF1 = 0
000652 NAOHWMGF2 = 24*QF*(MGF*0.24*2/3*40*100)/(24.3*NAOHPC*997504.12)
000654 GOTO 664
000656 DMGF = (SIF-(0.5*PHSWR*997504.12*PHSPC)/(100*24*QF))*(24.3/(0.24*!
000658 2/3*60.1))
000660 NAOHWMGF1 =24*QF*(MGF-DMGF)*0.24*2*40*100/(24.3*NAOHPC*997504.12)
000662 NAOHWMGF2 = 24*QF*DMGF*0.24*2/3*40*100/(24.3*NAOHPC*997504.12)
000664 NAOHWMGF = NAOHWMGF1 + NAOHWMGF2
000666 MAF = (MAMU * QMU + MACR * QCR) / QF
000668 IF PAFT = MAF THEN GOTO 670     ELSE GOTO 672
000670 OHF = MAF : CARBF = 0 : BICARBF = 0 : GOTO 686
000672 IF PAFT > (.5 * MAF) THEN GOTO 674     ELSE GOTO 678
000674 OHF = 2 * PAFT : CARBF = 2 * (MAF - PAFT) : BICARBF = 0 : GOTO   !
000676 686
000678 IF PAFT = 0 THEN GOTO 680     ELSE GOTO 682
000680 OHF = 0 : CARBF = 0 : BICARBF = MAF : GOTO 686
000682 IF PAFT < (.5 * MAF) THEN GOTO 684     ELSE GOTO 686
000684 OHF = 0 : CARBF = 2 * PAFT : BICARBF = MAF - (2 * PAFT)
000686 FWOH = OHF + (BICARBF + 2 * CARBF) * CARBPC/100
000688 OHT = FWOH * CYC
000690 OHD = OHBD - OHT
000692 IF OHT > OHBD THEN GOTO 696     ELSE GOTO 694
000694 DNAOHWR = 0 : GOTO 698
000696 DNAOHWR = 24*QBD*((OHT-OHBD)*0.34*40*100)/(17*NAOHPC*997504.12)
000698 IF OHD < 0 THEN GOTO 700     ELSE GOTO 702
000700 NAOHWR = 0 : GOTO 704
000702 NAOHWR = (24*QBD*OHD*0.34*40*100)/(17*NAOHPC*997504.12)
000704 NAOHWPH = PHSW * PHSNOH / NAOHPC
000706 IF PHSW > 0 THEN GOTO 708   ELSE GOTO 712
000708 NAOHWCAF = 24*QF*(CAF*0.2*0.4*40/40.1)/(NAOHPC/100*997504.12)
```

```
000710 SODASHW = 0 : GOTO 720
000712 IF CAF > (0.5*BICARBF*1.22/61+CARBF*0.6/60)*40.1/.4*(100-CARBPC) !
000714 /100 THEN GOTO 716     ELSE GOTO 720
000716 SODASHW = 24*QF*((CAF*0.4*60/40.1)-(0.5*BICARBF*1.22*60/61+CARBF*!
000718 0.6)*CARBPC/100)*106/(60*997504.12)
000720 NAOHW = NAOHWPH + NAOHWCAF + NAOHWMGF + NAOHWR - DNAOHWR
000722 LSNWR = 24*QBD*LSNBD*100/(LSNPC*997504.12)
000724 LSNWMAF = 24*QBD*0.2*MAF*100/(LSNPC*997504.12)
000726 IF LSNWR >= LSNWMAF THEN LSNW = LSNWR
000728 IF LSNWR < LSNWMAF THEN LSNW = LSNWMAF
000730 SFWR(N) = 24*QBD*SFBD*126.1*100/(80.1*SFPC*997504.12)
000732 SFWOX(N) = (24*QF*OXF*126.1*100)/(16*SFPC*997504.12)
000734 SFW = SFWR(N) +SFWOX(N)
000736 CDOF = (BICARBF * (1 + CARBPC/100) / 2 * 1.22 * 44/61) +          !
000738 (CARBF * CARBPC/100 * 0.6 * 44/60)
000740 CHAF = 1.1^ * CDOF
000742 MORF = 0.99 * CDOF
000744 CHAPCBD = 0.2 / (1.0 + CHADR)
000746 MORPCBD = 0.2 / (1.0 + MORDR)
000748 CHAW = (QF+QBD*CYC*CHAPCBD)*((0.2*24*CHAF*100)/(CHAPC*997504.12))
000750 MORW = (QF+QBD*CYC*MORPCBD)*((0.2*24*MORF*100)/(MORPC*997504.12))
000752 ***  SIGN CONVENTION USED IN DXXXXXX CALCULATIONS BELOW ARE
000754 *       + IF IT ADDS TO THE QUANTITY IN THE BOILER
000756 *       - IF IT REDUCES THE QUANTITY IN THE BOILER
000758 ***  DETERMINE EFFECTS ON TDS - REACTIONS COVERED INCLUDE
000760 *       LIGNOSULFONATE (PURE AND IMPURE), SULFITE (PURE,IMPURE AND
000762 *       COMBINED OXYGEN), CALCIUM REACTIONS (PURE AND IMPURE),
000764 *       MAGNESIUM REACTIONS (PURE AND IMPURE), SILICA, AND CAUSTIC
000766 *       SODA (PURE AND IMPURE)
000768 DTDSLSN = LSNW*997504.12/(24*QMU)
000770 DTDSSF = (SFWR(N)+(SFWOX(N)*SFPC*142/(100*126.1))+((100-SFPC)*    !
000772 SFWOX(N)/100))*997504.12/(24*QMU)
000774 IF PHSW = 0 THEN GOTO 776     ELSE GOTO 780
000776 DTDSCAF = -(CAF*0.4/40.1*100.1*QF/QMU)+(SODASHW*997504.12*46)/    !
000778 (106*24*QMU)
000780 IF PHSW > 0 THEN GOTO 782      ELSE GOTO 786
000782 DTDSCAF = -(CAF*0.4*QF/QMU)+((PHSWCAF*(100-PHSPC)/100)+PHSWR)*    !
000784 997504.12/(24*QMU)
000786 IF MGF > 0 THEN GOTO 790     ELSE GOTO 788
000788 DTDSMGF = 0 : GOTO 794
000790 DTDSMGF = -((NAOHWMGF1*24.3)+(NAOHWMGF2*225.1))*(0.5*997504.12*   !
000792 NAOHPC)/(40*100*24*QMU)
000794 IF NAOHW >= 0 THEN GOTO 796    ELSE GOTO 802
000796 DTDSOH = (NAOHWPH+NAOHWCAF+NAOHWMGF)*((NAOHPC*23)/(100*40)+(100- !
000798 NAOHPC)/100)*997504.12/(24*QMU) + (NAOHWR-DNAOHWR)*997504.12/(24*!
000800 QMU) : GOTO 804
000802 DTDSOH = 0
000804 ***  DETERMINE EFFECTS ON SIO2 - REACTIONS COVERED INCLUDE ONLY
000806 *       THAT REDUCED BY THE PRODUCTION OF SERPENTINE WHICH IS IN
000808 *       THE CALCULATION OF DSIMU(N) DIRECTLY
000810 ***  DETERMINE EFFECTS ON TSS - REACTIONS COVERED INCLUDE CALCIUM
000812 *       CARBONATE, HYDROXYAPATITE, BRUCITE, AND SERPENTINE
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000814 IF PHSW > 0 THEN GOTO 826     ELSE GOTO 816
000816 IF CAF <= ((0.5*BICARBF*1.22/61)+(CARBF*0.6/60))*(40.1*(100-     !
000818 CARBF)/(0.4*100)) THEN GOTO 820     ELSE GOTO 822
000820 DTSSCAF = CAF*0.4*100.1*QF/(40.1*QMU) : GOTO 828
000822 DTSSCAF = ((0.5*BICARBF*1.22/61)+(CARBF*0.6/60))*100.1*QF/QMU :  !
000824 GOTO 828
000826 DTSSCAF =  0.1*CAF*0.4*1005*QF/(40.1*QMU)
000828 IF MGF > 0 THEN GOTO 832    ELSE GOTO 830
000830 DTSSMGF = 0 : GOTO 836
000832 DTSSMGF = ((NAOHWMGF1*58.3/40)+(NAOHWMGF2*277.1/40))*(0.5*       !
000834 NAOHPC*997504.12)/(24*100*QMU)
000836 DTDSMU(N) =  DTDSLSN + DTDSSF + DTDSCAF + DTDSMGF + DTDSOH
000838 DSIMU(N) = -(NAOHWMGF2*997504.12*NAOHPC*60.1)/(100*40*24*QMU)
000840 DTSSMU(N) =  DTSSCAF + DTSSMGF
000842 IF Z$ = "N" THEN GOTO 846
000844 IF (Z$ = "Y") AND (N <= 2) THEN GOTO NEXT2 ELSE GOTO NEXT3
000846 IF ABS(CHEMCYC(M)-CHEMCYC(N)) < 0.0000001 THEN GOTO NEXT3  ELSE  !
000848 GOTO NEXT2
000850 NEXT2 : PRINT "ITERATION = ",N
000852 PRINT USING LYT12,                                               !
000854 "CYCLES OF CONCENTRATION - PREVIOUS RUN     =      ",CHEMCYC(M)
000856 PRINT USING LYT12,                                               !
000858 "CYCLES OF CONCENTRATION - THIS RUN         =      ",CHEMCYC(N)
000860 N = N + 1 : PRINT : GOTO ITERAUTO
000862 NEXT3 : PRINT
000864 ***   MAKEUP BASED UPON TOTAL DISSOLVED SOLIDS
000866 *
000868 PRINT : PRINT USING LYT5 ,                                       !
000870 "MAKEUP (POUNDS/HOUR QMU) BASED ON TDS       =     ",QMUTDS
000872 ***   MAKEUP BASED UPON TOTAL SUSPENDED SOLIDS
000874 *
000876 PRINT USING LYT5 ,                                               !
000878 "MAKEUP (POUNDS/HOUR QMU) BASED ON SIO2      =     ",QMUSI
000880 ***   MAKEUP BASED UPON TOTAL SUSPENDED SOLIDS
000882 *
000884 PRINT USING LYT5 ,                                               !
000886 "MAKEUP (POUNDS/HOUR QMU) BASED ON TSS       =     ",QMUTSS
000888 IF Z$ = "N" THEN GOTO 896
000890 PRINT USING LYT5 ,                                               !
000892 "MAKEUP CONSTRAINED TO THE FOLLOWING VALUE (LB/HR) ",QMUC :      !
000894 GOTO 910
000896 IF QMUTDS >= QMUSI THEN GOTO 900
000898 IF QMUSI > QMUTDS THEN GOTO 906
000900 PRINT USING LYT5 ,                                               !
000902 "MAKEUP LIMITED BY TDS (POUNDS/HOUR QMU)     =     ",QMUTDS
000904 GOTO 910
000906 PRINT USING LYT5 ,                                               !
000908 "MAKEUP LIMITED BY SIO2 (POUNDS/HOUR QMU)    =     ",QMUSI
000910 IF QMUTSS > QMU THEN GOTO 912     ELSE GOTO 914
000912 PRINT WARNTSS1$ : PRINT WARNTSS2$ : PRINT WARNTSS3$ : PRINT
000914 PRINT WARNQMU1$ : PRINT
000916 ***   DETERMINE FEEDWATER QUALITY
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000918 *       FOR COMPARISON TO ACTUAL TESTING
000920 PRINT WARNC1$ : PRINT
000922 PRINT USING LYT5 ,                                                    !
000924 "FEEDWATER (POUNDS/HOUR QF)                    =     ",QF
000926 PRINT USING LYT8 ,                                                    !
000928 "CALCULATED TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM)  =",TDSF
000930 PRINT USING LYT8 ,                                                    !
000932 "TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) BY TEST     =",TDSFT
000934 PRINT
000936 PRINT USING LYT8 ,                                                    !
000938 "CALCULATED SILICA IN FEEDWATER (PPM SIO2)             =",SIF
000940 PRINT USING LYT8 ,                                                    !
000942 "SILICA IN FEEDWATER (PPM SIO2) BY TEST                =",SIFT
000944 PRINT
000946 PRINT USING LYT8 ,                                                    !
000948 "CALCULATED TOTAL SUSPENDED SOLIDS IN FEEDWATER (PPM)  =",TSSF
000950 ***   DETERMINE CYCLES OF CONCENTRATION
000952 *
000954 PRINT : PRINT USING LYT5 ,                                            !
000956 "CYCLES BASED ON TDS - DESIGN LIMIT          =     ",CYCTDSD
000958 IF SIFE<=0 THEN PRINT "  BOILER IS NOT SILICA LIMITED!"
000960 IF SIFE<=0 THEN GOTO 966
000962 PRINT USING LYT5 ,                                                    !
000964 "CYCLES BASED ON SILICA - DESIGN LIMIT       =     ",CYCSID
000966 IF TSSFE<=0 THEN PRINT "  BOILER IS NOT SUSPENDED SOLIDS LIMITED!"
000968 IF TSSFE<=0 THEN GOTO 986
000970 PRINT USING LYT5 ,                                                    !
000972 "CYCLES BASED ON TSS - DESIGN LIMIT          =     ",CYCTSSD
000974 PRINT USING LYT5 ,                                                    !
000976 "ACTUAL CYCLES BASED ON TDS                  =     ",CYCTDSA
000978 PRINT USING LYT5 ,                                                    !
000980 "ACTUAL CYCLES BASED ON SILICA               =     ",CYCSIA
000982 PRINT USING LYT5 ,                                                    !
000984 "ACTUAL CYCLES BASED ON TSS                  =     ",CYCTSSA
000986 PRINT USING LYT5 ,                                                    !
000988 "OPERATING CYCLES OF CONCENTRATION (QF/QBD)  =     ",CYC
000990 PRINT
000992 PRINT USING LYT5 ,                                                    !
000994 "OPERATING BOILER TDS                        =     ",BLRTDS
000996 PRINT USING LYT5 ,                                                    !
000998 "OPERATING BOILER SILICA                     =     ",BLRSI
001000 PRINT USING LYT5 ,                                                    !
001002 "OPERATING BOILER TSS                        =     ",BLRTSS
001004 PRINT
001006 *****     DETERMINE BLOWDOWN
001008 *
001010 PRINT "  BLOWDOWN IS TAKEN FROM BOTTOM OF MUD DRUM (100%) OR"
001012 PRINT "    FROM CONTINUOUS LINE AT STEAM WATER INTERFACE (90%)"
001014 PRINT "    AND BOTTOM OF MUD DRUM (10%)"
001016 PRINT
001018 PRINT USING LYT5 ,                                                    !
001020 "BLOWDOWN (POUNDS/HOUR QBD: QMU - QL)        =     ",QBD
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001022 PRINT
001024 *****     DETERMINE PHOSPHATE DOSAGE
001026 *
001028 PRINT "PHOSPHATE CHEMICAL USED  ",PHS$
001030 PRINT USING LYT8 ,                                                    !
001032 "PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL      =    ",PHSPC
001034 PRINT "POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS !
001036 OF PHOSPHATE CHEMICAL "
001038 PRINT USING LYT3 ,                                                    !
001040 "              =     ",PHSNOH
001042 PRINT
001044 PRINT USING LYT8 ,                                                    !
001046 "CALCULATED CALCIUM HARDNESS IN FEEDWATER (PPM CACO3) =",CAF
001048 PRINT USING LYT8 ,                                                    !
001050 "CALCIUM HARDNESS IN FEEDWATER (PPM CACO3) BY TEST    =",CAFT
001052 PRINT
001054 PRINT USING LYT5 ,                                                    !
001056 "RESIDUAL PO4 DESIRED IN BOILER    (PPM PO4)     =",PHSBD
001058 PRINT USING LYT5 ,                                                    !
001060 "POUNDS OF PHOSPHATE CHEMICAL/DAY FOR RESIDUAL   = ",PHSWR
001062 PRINT USING LYT5 ,                                                    !
001064 "POUNDS OF PO4 CHEMICAL/DAY FOR CALCIUM HARDNESS = ",PHSWCAF
001066 PRINT USING LYT5 ,                                                    !
001068 "TOTAL POUNDS OF PHOSPHATE CHEMICAL/DAY          = ",PHSW
001070 IF PHSW > 0 THEN GOTO 1072     ELSE GOTO 1088
001072 IF LBPHS > 0 THEN GOTO 1076    ELSE GOTO 1074
001074 IF LBOTHPHS > 0 THEN GOTO 1082    ELSE GOTO 1088
001076 PRINT USING LYT5 ,                                                    !
001078 "ACTUAL DOSAGE OF PHOSPHATE CHEMICAL     (LB/DAY)= ",LBPHS
001080 GOTO 1088
001082 PRINT "ALTERNATE PHOSPHATE CHEMICAL USED   =   ",OTHPHS$
001084 PRINT USING LYT5 ,                                                    !
001086 "ACTUAL DOSAGE OF ALTERNATE PO4 CHEMICAL (LB/DAY)= ",LBOTHPHS
001088 PRINT
001090 *****     DETERMINE THE CAUSTIC SODA DOSAGE
001092 *
001094 PRINT USING LYT5 ,                                                    !
001096 "CALCULATED MAGNESIUM HARDNESS IN FEEDWATER   =    ",MGF
001098 PRINT USING LYT5 ,                                                    !
001100 "CALCULATED SILICA IN FEEDWATER              =     ",SIF
001102 PRINT USING LYT5 ,                                                    !
001104 "SILICA IN FEEDWATER BY TEST                 =     ",SIFT
001106 PRINT USING LYT5 ,                                                    !
001108 "FEEDWATER SILICA NEEDED FOR MAGNESIUM REACTIONS = ",SINHD
001110 PRINT
001112 PRINT USING LYT5 ,                                                    !
001114 "NAOH POUNDS/DAY FOR MAGNESIUM HYDROXIDE      =    ",NAOHWMGF1
001116 PRINT USING LYT5 ,                                                    !
001118 "NAOH POUNDS/DAY FOR SERPENTINE               =    ",NAOHWMGF2
001120 PRINT USING LYT5 ,                                                    !
001122 "TOTAL NAOH POUNDS/DAY FOR MAGNESIUM REACTIONS  =  ",NAOHWMGF
001124 PRINT
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001126 IF SIF > SINHD THEN GOTO 1128    ELSE GOTO 1130
001128 PRINT WARNF1$ : PRINT : GOTO 1132
001130 PRINT WARNF2$ : PRINT
001132 ***  DETERMINE FEEDWATER ALKALINITY QUANTITIES
001134 *
001136 IF OHD >= 0 THEN GOTO 1138    ELSE GOTO 1160
001138 PRINT USING LYT5 ,                                                    !
001140 "HYDROXYL RESIDUAL DESIRED                    =     ",OHBD
001142 PRINT USING LYT5 ,                                                    !
001144 "HYDROXYL RESIDUAL BY TEST                    =     ",OHBDT
001146 PRINT "BREAKDOWN OF NATURALLY OCCURRING ALKALINITY GIVES"
001148 PRINT USING LYT5 ,                                                    !
001150 "TOTAL ESTIMATED HYDROXYL ALKALINITY IN BOILER =    ",OHT
001152 PRINT WARNOH6$:PRINT WARNOH7$:PRINT WARNOH8$:PRINT WARNOH9$
001154 PRINT USING LYT5 ,                                                    !
001156 "HYDROXYL DEFICIENCY (PPM CACO3)              =     ",OHD
001158 PRINT : GOTO 1190
001160 PRINT WARNOH1$ : PRINT
001162 PRINT USING LYT5 ,                                                    !
001164 "HYDROXYL RESIDUAL DESIRED                    =     ",OHBD
001166 PRINT USING LYT5 ,                                                    !
001168 "HYDROXYL RESIDUAL BY TEST                    =     ",OHBDT
001170 PRINT "BREAKDOWN OF NATURALLY OCCURRING ALKALINITY GIVES"
001172 PRINT USING LYT5 ,                                                    !
001174 "TOTAL ESTIMATED HYDROXYL ALKALINITY IN BOILER =    ",OHT
001176 PRINT WARNOH6$:PRINT WARNOH7$:PRINT WARNOH8$:PRINT WARNOH9$
001178 PRINT : IF OHT > 500 THEN GOTO 1180   ELSE GOTO 1182
001180 PRINT WARNOH2$ : PRINT WARNOH3$ : PRINT
001182 IF OHT > OHBD THEN GOTO 1184    ELSE GOTO 1190
001184 PRINT "ESTIMATED REDUCTION IN NAOH (POUNDS/DAY) DUE TO NATURALLY"
001186 PRINT USING LYT5 ,                                                    !
001188 "OCCURRING ALKALINITY                           =    ",DNAOHWR
001190 PRINT : IF OHD >= 0 THEN GOTO 1192    ELSE GOTO 1196
001192 PRINT USING LYT5 ,                                                    !
001194 "NAOH POUNDS/DAY FOR RESIDUAL                 =     ",NAOHWR
001196 PRINT USING LYT5 ,                                                    !
001198 "NAOH POUNDS/DAY FOR PO4 HYDROLYSIS-ADVANCED CALC =",NAOHWPH
001200 IF PHSW > 0 THEN GOTO 1202    ELSE GOTO 1208
001202 PRINT USING LYT5 ,                                                    !
001204 "NAOH POUNDS/DAY FOR CALCIUM REACTIONS        =     ",NAOHWCAF
001206 GOTO 1222
001208 IF CAF > (0.5*BICARBF*1.22/61+CARBF*0.6/60)*40.1/.4*(100-CARBPC) !
001210 /100 THEN GOTO 1212    ELSE GOTO 1222
001212 PRINT WARNPHS1$ : PRINT WARNPHS2$ : PRINT
001214 PRINT "POUNDS/DAY OF PURE SODIUM CARBONATE (SODA ASH) FOR"
001216 PRINT USING LYT5 ,                                                    !
001218 "CALCIUM REACTIONS WITHOUT PHOSPHATE AVAILABLE  =  ",SODASHW
001220 PRINT
001222 PRINT USING LYT5 ,                                                    !
001224 "PURITY (%) OF CAUSTIC SODA USED              =     ",NAOHPC
001226 IF NAOHW >= 0 THEN GOTO 1228    ELSE GOTO 1234
001228 PRINT USING LYT5 ,                                                    !
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001230 "TOTAL CAUSTIC SODA POUNDS/DAY-ADVANCED CALC    =  ",NAOHW
001232 GOTO 1240
001234 PRINT "* NO CAUSTIC SODA REQUIRED!"
001236 PRINT USING LYT5 ,                                              !
001238 "  CAN REDUCE EQUIVALENT CAUSTIC SODA POUNDS/DAY BY",NAOHW
001240 IF NAOHW >= 0 THEN GOTO 1242     ELSE GOTO 1258
001242 IF LBOH > 0 THEN GOTO 1246    ELSE GOTO 1244
001244 IF LBOTHOH > 0 THEN GOTO 1252    ELSE GOTO 1258
001246 PRINT USING LYT5 ,                                              !
001248 "ACTUAL DOSAGE OF CAUSTIC SODA           (LB/DAY)= ",LBOH
001250 GOTO 1258
001252 PRINT "ALTERNATE OH ALKALINITY CHEMICAL USED  =  ",OTHOH$
001254 PRINT USING LYT5 ,                                              !
001256 "ACTUAL DOSAGE OF ALTERNATE OH CHEMICAL (LB/DAY) = ",LBOTHOH
001258 PRINT
001260 ***   DETERMINE LIGNOSULFONATE DOSAGE
001262 *
001264 PRINT USING LYT4 ,                                              !
001266 "RESIDUAL PPM LIGNOSULFONATE DESIRED    =     ",LSNBD
001268 PRINT USING LYT4 ,                                              !
001270 "PURITY (%) OF LIGNOSULFONATE CHEMICAL  =     ",LSNPC
001272 PRINT USING LYT5 ,                                              !
001274 "LIGNOSULFONATE POUNDS/DAY FOR RESIDUAL (MINIMUM) =",LSNWR
001276 PRINT USING LYT5 ,                                              !
001278 "LIGNOSULFONATE DOSAGE FOR FDWTR 20 % M ALKALINITY=",LSNWMAF
001280 PRINT USING LYT5 ,                                              !
001282 "LIGNOSULFONATE DOSAGE REQUIRED PER DAY      =     ",LSNW
001284 IF LSNW > 0 THEN GOTO 1286     ELSE GOTO 1302
001286 IF LBLSN > 0 THEN GOTO 1290    ELSE GOTO 1288
001288 IF LBOTHLSN > 0 THEN GOTO 1296    ELSE GOTO 1302
001290 PRINT USING LYT5 ,                                              !
001292 "ACTUAL DOSAGE OF LIGNOSULFONATE         (LB/DAY)= ",LBLSN
001294 GOTO 1302
001296 PRINT "ALTERNATE SLUDGE CONDITIONER USED   =   ",OTHLSN$
001298 PRINT USING LYT5 ,                                              !
001300 "ACTUAL DOSAGE OF SLUDGE CONDITIONER    (LB/DAY) = ",LBOTHLSN
001302 PRINT
001304 ***   DETERMINE SULFITE DOSAGE
001306 *
001308 *  GOSUB TO TEST DEAERATING HEATER FOR PROPER OPERATION
001310 GOSUB DAOPS
001312 PRINT USING LYT4 ,                                              !
001314 "RESIDUAL SULFITE (PPM SO3) DESIRED     =     ",SFBD
001316 PRINT USING LYT4 ,                                              !
001318 "PURITY (%) OF SULFITE CHEMICAL         =     ",SFPC
001320 PRINT USING LYT5 ,                                              !
001322 "SODIUM SULFITE NEEDED FOR RESIDUAL          =     ",SFWR(N)
001324 PRINT USING LYT5 ,                                              !
001326 "SODIUM SULFITE NEEDED FOR OXYGEN LEAKAGE    =     ",SFWOX(N)
001328 PRINT USING LYT5 ,                                              !
001330 "SODIUM SULFITE REQUIRED (POUNDS/DAY)        =     ",SFW
001332 IF SFW > 0 THEN GOTO 1334     ELSE GOTO 1350
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001334 IF LBSF > 0 THEN GOTO 1338    ELSE GOTO 1336
001336 IF LBOTHSF > 0 THEN GOTO 1344    ELSE GOTO 1350
001338 PRINT USING LYT5 ,                                                    !
001340 "ACTUAL DOSAGE OF SODIUM SULFITE          (LB/DAY)= ",LBSF
001342 GOTO 1350
001344 PRINT "ALTERNATE OXYGEN SCAVENGER USED   =   ",OTHSF$
001346 PRINT USING LYT5 ,                                                    !
001348 "ACTUAL DOSAGE OF OXYGEN SCAVENGER USED (LB/DAY) = ",LBOTHSF
001350 PRINT
001352 ***   DETERMINE NEUTRALIZING AMINE DOSAGE
001354 *       FOR A 50/50 MIXTURE OF CYCLOHEXYLAMINE AND MORPHOLINE
001356 *
001358 *
001360 * ASSUME 20% OF AMINE PREDICTED BY DISTRIBUTION RATIO IN BOILER
001362 *   WILL BE BLOWNDOWN AND LOST
001364 *  PPM AMINE LOST IN BLOWDOWN = AMINE RESIDUAL IN BOILER AT
001366 *   OPERATING CYCLES OF CONCENTRATION * 1/(1+DR) * 0.20
001368 *
001370 PRINT USING LYT5 ,                                                     !
001372 "CALCULATED M ALKALINITY IN FEEDWATER        =     ",MAF
001374 PRINT USING LYT5 ,                                                    !
001376 "M ALKALINITY IN FEEDWATER BY TEST           =     ",MAFT
001378 PRINT
001380 PRINT USING LYT5 ,                                                    !
001382 "P ALKALINITY IN FEEDWATER BY TEST           =     ",PAFT
001384 PRINT USING LYT5 ,                                                    !
001386 "CALCULATED FEEDWATER BICARBONATE ALKALINITY =     ",BICARBF
001388 PRINT USING LYT5 ,                                                    !
001390 "CALCULATED FEEDWATER CARBONATE ALKALINITY   =     ",CARBF
001392 PRINT USING LYT5 ,                                                    !
001394 "EQUIV FEEDWATER CARBON DIOXIDE (PPM CO2)    =     ",CDOF
001396 PRINT
001398 PRINT USING LYT5 ,                                                    !
001400 "APPROX. CYCLOHEXYLAMINE DOSAGE (LB/DAY-50/50 MIX)=",CHAW
001402 PRINT USING LYT5 ,                                                    !
001404 "APPROX. MORPHOLINE DOSAGE      (LB/DAY-50/50 MIX)=",MORW
001406 PRINT WARNNA1$ : PRINT WARNNA2$ : PRINT
001408 PRINT WARNNA3$ : PRINT WARNNA4$ : PRINT
001410 IF (CHAW > 0 OR MORW > 0) THEN GOTO 1412     ELSE GOTO DEC3
001412 IF (LBCHA > 0 OR LBMOR > 0) THEN GOTO 1416    ELSE GOTO 1414
001414 IF LBOTHAM > 0 THEN GOTO 1426    ELSE GOTO DEC3
001416 PRINT USING LYT5 ,                                                    !
001418 "ACTUAL DOSAGE OF CYCLOHEXYLAMINE         (LB/DAY)= ",LBCHA
001420 PRINT USING LYT5 ,                                                    !
001422 "ACTUAL DOSAGE OF MORPHOLINE              (LB/DAY)= ",LBMOR
001424 GOTO DEC3
001426 PRINT "ALTERNATE NEUTRALIZING AMINE USED   =   ",OTHAM$
001428 PRINT USING LYT5 ,                                                    !
001430 "ACTUAL DOSAGE OF NEUTRALIZING AMINE    (LB/DAY) = ",LBOTHAM
001432 DEC3 : Y$ = "QQ" :PRINT:PRINT:PRINT
001434 PRINT : PRINT "FURTHER ANALYSIS OF CHEMICAL DOSAGES IS AVAILABLE !
001436 IN THE PRINTOUT." :PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
```

```
001438 ACCEPT                                                              !
001440 AT(5,5), "DO YOU WANT A PRINTOUT OF THIS RUN ? ",Y$,CH(1),          !
001442 AT(7,5), "  (Y) IF YOU WANT A PRINTOUT",                            !
001444 AT(8,5), "  (N) IF YOU WANT TO RETURN TO PREVIOUS MENU",             !
001446 AT(11,1),  "PRESS <ENTER> TO CONTINUE",                             !
001448 AT(15,1),"NOTE - TWO BELLS INDICATE PRINT FILE ACCESSED",           !
001450 AT(16,1),"       SCREEN THEN RETURNS TO PREVIOUS MENU",             !
001452 KEYS(BIN(0))
001454 IF Y$ = "Y" THEN GOTO NEXT4
001456 IF Y$ = "N" THEN GOTO EXIT1 ELSE GOTO DEC3
001458 NEXT4 : DISPLAY BELL : DISPLAY BELL : SELECT PAUSE : GOTO PRINTRUN
001460 EXIT1 : SELECT PAUSE 10 : CLOSE #1 : END
001462 *
001464 DAOPS:
001466 *
001468 ***   SUBROUTINE TO DETERMINE DEAERATING HEATER OPERATION
001470 IF PDA =  0.0 THEN GOTO 1472    ELSE GOTO 1476
001472 IF TF >= (209.99 - AMSL/500) AND TF <= (213.99 - AMSL/500) THEN  !
001474 GOTO 1724    ELSE GOTO 1716
001476 IF PDA =  0.5 THEN GOTO 1478    ELSE GOTO 1482
001478 IF TF >= (211.67 - AMSL/500) AND TF <= (215.67 - AMSL/500) THEN  !
001480 GOTO 1724    ELSE GOTO 1716
001482 IF PDA =  1.0 THEN GOTO 1478    ELSE GOTO 1488
001484 IF TF >= (213.31 - AMSL/500) AND TF <= (217.31 - AMSL/500) THEN  !
001486 GOTO 1724    ELSE GOTO 1716
001488 IF PDA =  1.5 THEN GOTO 1490    ELSE GOTO 1494
001490 IF TF >= (214.92 - AMSL/500) AND TF <= (218.92 - AMSL/500) THEN  !
001492 GOTO 1724    ELSE GOTO 1716
001494 IF PDA =  2.0 THEN GOTO 1496    ELSE GOTO 1500
001496 IF TF >= (216.48 - AMSL/500) AND TF <= (220.48 - AMSL/500) THEN  !
001498 GOTO 1724    ELSE GOTO 1716
001500 IF PDA =  2.5 THEN GOTO 1502    ELSE GOTO 1506
001502 IF TF >= (218.01 - AMSL/500) AND TF <= (222.01 - AMSL/500) THEN  !
001504 GOTO 1724    ELSE GOTO 1716
001506 IF PDA =  3.0 THEN GOTO 1508    ELSE GOTO 1512
001508 IF TF >= (219.50 - AMSL/500) AND TF <= (223.50 - AMSL/500) THEN  !
001510 GOTO 1724    ELSE GOTO 1716
001512 IF PDA =  3.5 THEN GOTO 1514    ELSE GOTO 1518
001514 IF TF >= (220.96 - AMSL/500) AND TF <= (224.96 - AMSL/500) THEN  !
001516 GOTO 1724    ELSE GOTO 1716
001518 IF PDA =  4.0 THEN GOTO 1520    ELSE GOTO 1524
001520 IF TF >= (222.38 - AMSL/500) AND TF <= (224.38 - AMSL/500) THEN  !
001522 GOTO 1724    ELSE GOTO 1716
001524 IF PDA =  4.5 THEN GOTO 1526    ELSE GOTO 1530
001526 IF TF >= (223.77 - AMSL/500) AND TF <= (227.77 - AMSL/500) THEN  !
001528 GOTO 1724    ELSE GOTO 1716
001530 IF PDA =  5.0 THEN GOTO 1532    ELSE GOTO 1536
001532 IF TF >= (225.13 - AMSL/500) AND TF <= (229.13 - AMSL/500) THEN  !
001534 GOTO 1724    ELSE GOTO 1716
001536 IF PDA =  5.5 THEN GOTO 1538    ELSE GOTO 1542
001538 IF TF >= (226.47 - AMSL/500) AND TF <= (230.47 - AMSL/500) THEN  !
001540 GOTO 1724    ELSE GOTO 1716
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001542 IF PDA =  6.0 THEN GOTO 1544    ELSE GOTO 1548
001544 IF TF >= (227.78 - AMSL/500) AND TF <= (231.78 - AMSL/500) THEN  !
001546 GOTO 1724    ELSE GOTO 1716
001548 IF PDA =  6.5 THEN GOTO 1550    ELSE GOTO 1554
001550 IF TF >= (229.06 - AMSL/500) AND TF <= (233.06 - AMSL/500) THEN  !
001552 GOTO 1724    ELSE GOTO 1716
001554 IF PDA =  7.0 THEN GOTO 1556    ELSE GOTO 1560
001556 IF TF >= (230.32 - AMSL/500) AND TF <= (234.32 - AMSL/500) THEN  !
001558 GOTO 1724    ELSE GOTO 1716
001560 IF PDA =  7.5 THEN GOTO 1562    ELSE GOTO 1566
001562 IF TF >= (231.55 - AMSL/500) AND TF <= (235.55 - AMSL/500) THEN  !
001564 GOTO 1724    ELSE GOTO 1716
001566 IF PDA =  8.0 THEN GOTO 1568    ELSE GOTO 1572
001568 IF TF >= (232.76 - AMSL/500) AND TF <= (236.76 - AMSL/500) THEN  !
001570 GOTO 1724    ELSE GOTO 1716
001572 IF PDA =  8.5 THEN GOTO 1574    ELSE GOTO 1578
001574 IF TF >= (233.95 - AMSL/500) AND TF <= (237.95 - AMSL/500) THEN  !
001576 GOTO 1724    ELSE GOTO 1716
001578 IF PDA =  9.0 THEN GOTO 1580    ELSE GOTO 1584
001580 IF TF >= (235.11 - AMSL/500) AND TF <= (239.11 - AMSL/500) THEN  !
001582 GOTO 1724    ELSE GOTO 1716
001584 IF PDA =  9.5 THEN GOTO 1586    ELSE GOTO 1590
001586 IF TF >= (236.26 - AMSL/500) AND TF <= (240.26 - AMSL/500) THEN  !
001588 GOTO 1724    ELSE GOTO 1716
001590 IF PDA = 10.0 THEN GOTO 1592    ELSE GOTO 1596
001592 IF TF >= (237.39 - AMSL/500) AND TF <= (241.39 - AMSL/500) THEN  !
001594 GOTO 1724    ELSE GOTO 1716
001596 IF PDA = 10.5 THEN GOTO 1598    ELSE GOTO 1602
001598 IF TF >= (238.51 - AMSL/500) AND TF <= (242.51 - AMSL/500) THEN  !
001600 GOTO 1724    ELSE GOTO 1716
001602 IF PDA = 11.0 THEN GOTO 1604    ELSE GOTO 1608
001604 IF TF >= (239.60 - AMSL/500) AND TF <= (243.60 - AMSL/500) THEN  !
001606 GOTO 1724    ELSE GOTO 1716
001608 IF PDA = 11.5 THEN GOTO 1610    ELSE GOTO 1614
001610 IF TF >= (240.67 - AMSL/500) AND TF <= (244.67 - AMSL/500) THEN  !
001612 GOTO 1724    ELSE GOTO 1716
001614 IF PDA = 12.0 THEN GOTO 1616    ELSE GOTO 1620
001616 IF TF >= (241.73 - AMSL/500) AND TF <= (245.73 - AMSL/500) THEN  !
001618 GOTO 1724    ELSE GOTO 1716
001620 IF PDA = 12.5 THEN GOTO 1622    ELSE GOTO 1626
001622 IF TF >= (242.77 - AMSL/500) AND TF <= (246.77 - AMSL/500) THEN  !
001624 GOTO 1724    ELSE GOTO 1716
001626 IF PDA = 13.0 THEN GOTO 1628    ELSE GOTO 1632
001628 IF TF >= (243.80 - AMSL/500) AND TF <= (247.80 - AMSL/500) THEN  !
001630 GOTO 1724    ELSE GOTO 1716
001632 IF PDA = 13.5 THEN GOTO 1634    ELSE GOTO 1638
001634 IF TF >= (244.81 - AMSL/500) AND TF <= (248.81 - AMSL/500) THEN  !
001636 GOTO 1724    ELSE GOTO 1716
001638 IF PDA = 14.0 THEN GOTO 1640    ELSE GOTO 1644
001640 IF TF >= (245.81 - AMSL/500) AND TF <= (249.81 - AMSL/500) THEN  !
001642 GOTO 1724    ELSE GOTO 1716
001644 IF PDA = 14.5 THEN GOTO 1646    ELSE GOTO 1650
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001646 IF TF >= (246.79 - AMSL/500) AND TF <= (250.79 - AMSL/500) THEN  !
001648 GOTO 1724     ELSE GOTO 1716
001650 IF PDA = 15.0 THEN GOTO 1652     ELSE GOTO 1656
001652 IF TF >= (247.75 - AMSL/500) AND TF <= (251.75 - AMSL/500) THEN  !
001654 GOTO 1724     ELSE GOTO 1716
001656 IF PDA = 15.5 THEN GOTO 1658     ELSE GOTO 1662
001658 IF TF >= (248.71 - AMSL/500) AND TF <= (252.71 - AMSL/500) THEN  !
001660 GOTO 1724     ELSE GOTO 1716
001662 IF PDA = 16.0 THEN GOTO 1664     ELSE GOTO 1668
001664 IF TF >= (249.66 - AMSL/500) AND TF <= (253.66 - AMSL/500) THEN  !
001666 GOTO 1724     ELSE GOTO 1716
001668 IF PDA = 16.5 THEN GOTO 1670     ELSE GOTO 1674
001670 IF TF >= (250.59 - AMSL/500) AND TF <= (254.59 - AMSL/500) THEN  !
001672 GOTO 1724     ELSE GOTO 1716
001674 IF PDA = 17.0 THEN GOTO 1676     ELSE GOTO 1680
001676 IF TF >= (251.50 - AMSL/500) AND TF <= (255.50 - AMSL/500) THEN  !
001678 GOTO 1724     ELSE GOTO 1716
001680 IF PDA = 17.5 THEN GOTO 1682     ELSE GOTO 1686
001682 IF TF >= (252.41 - AMSL/500) AND TF <= (256.41 - AMSL/500) THEN  !
001684 GOTO 1724     ELSE GOTO 1716
001686 IF PDA = 18.0 THEN GOTO 1688     ELSE GOTO 1692
001688 IF TF >= (253.31 - AMSL/500) AND TF <= (257.31 - AMSL/500) THEN  !
001690 GOTO 1724     ELSE GOTO 1716
001692 IF PDA = 18.5 THEN GOTO 1694     ELSE GOTO 1698
001694 IF TF >= (254.19 - AMSL/500) AND TF <= (258.19 - AMSL/500) THEN  !
001696 GOTO 1724     ELSE GOTO 1716
001698 IF PDA = 19.0 THEN GOTO 1700     ELSE GOTO 1704
001700 IF TF >= (255.06 - AMSL/500) AND TF <= (259.06 - AMSL/500) THEN  !
001702 GOTO 1724     ELSE GOTO 1716
001704 IF PDA = 19.5 THEN GOTO 1706     ELSE GOTO 1710
001706 IF TF >= (255.93 - AMSL/500) AND TF <= (259.93 - AMSL/500) THEN  !
001708 GOTO 1724     ELSE GOTO 1716
001710 IF PDA = 20.0 THEN GOTO 1712
001712 IF TF >=(256.78 - AMSL/500) AND TF <=(260.78 - AMSL/500) THEN    !
001714 GOTO 1724      ELSE GOTO 1716
001716 PRINT WARNDA1$ : PRINT WARNDA2$
001718 PRINT USING LYT11,                                               !
001720 "DESIGN LIMIT PPM O2 FROM DEAERATOR NOT ACHIEVED  =     ",OXF
001722 PRINT : RETURN : REM SUBROUTINE DAOPS ENDS
001724 PRINT WARNDA3$
001726 PRINT USING LYT11,                                               !
001728 "DESIGN LIMITED EFFLUENT PPM O2 FROM DEAERATOR    =     ",OXF
001730 ***   SUBROUTINE TO PROVIDE PRINTOUT OF RESULTS
001732 *
001734 PRINTRUN : SELECT PRINTER
001736 PRINT PAGE
001738 PRINT "                        ACSC/AFESC/AFIT"
001740 PRINT "          PROGRAM FOR STEAM BOILER WATER TREATMENT"
001742 PRINT "           COMPUTATION OF DAILY CHEMICAL DOSAGES"
001744 PRINT "                ADVANCED TREATMENT ANALYSIS"
001746 PRINT
001748 PRINT "DOSAGES ARE CALCULATED ESTIMATES OF FINAL DOSAGES AT THE S!
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001750 YSTEM OPERATING POINT."
001752 PRINT "COMPARISON WITH ACTUAL DOSAGES WILL REVEAL SYSTEM OPERATIN!
001754 G EFFICIENCY AND"
001756 PRINT "TESTING ACCURACY.  ADJUSTING DATA RECORDS ALLOWS COMPARATI!
001758 VE ANALYSIS FOR"
001760 PRINT "PROPOSED SYSTEM IMPROVEMENTS OR REPAIR PROJECTS."
001762 PRINT
001764 PRINT USING LYT9 ,                                                !
001766 "INSTALLATION WHERE BOILER IS LOCATED    ",BASE$
001768 PRINT USING LYT9 ,                                                !
001770 "BUILDING NUMBER WHERE BOILER LOCATED    ",BLDG$
001772 PRINT USING LYT9 ,                                                !
001774 "BOILER DESIGNATION                      ",BLR$
001776 PRINT USING LYT9 ,                                                !
001778 "NAME OF PERSON MAKING THIS RUN          ",OPR$
001780 PRINT USING LYT10 ,                                               !
001782 "COMMENT DESCRIBING THIS DATA  ",COMMENT$
001784 PRINT
001786 PRINT "*****     MAKEUP WATER QUALITY OF INTEREST     *****"
001788 PRINT "*****          AFTER ALL PRETREATMENT          *****"
001790 PRINT
001792 PRINT USING LYT4 ,                                                !
001794 "CALCIUM HARDNESS            (PPM CACO3)     ",CAMU
001796 PRINT USING LYT4 ,                                                !
001798 "MAGNESIUM HARDNESS          (PPM CACO3)     ",MGMU
001800 PRINT USING LYT4 ,                                                !
001802 "M ALKALINITY                (PPM CACO3)     ",MAMU
001804 PRINT USING LYT4 ,                                                !
001806 "TOTAL DISSOLVED SOLIDS      (PPM)           ",TDSMU
001808 PRINT USING LYT4 ,                                                !
001810 "SILICA                      (PPM SIO2)      ",SIMU
001812 PRINT USING LYT4 ,                                                !
001814 "TOTAL SUSPENDED SOLIDS      (PPM)           ",TSSMU
001816 PRINT
001818 PRINT "*****     CONDENSATE RETURN QUALITY OF INTEREST     *****"
001820 PRINT
001822 PRINT USING LYT4 ,                                                !
001824 "CALCIUM HARDNESS            (PPM CACO3)     ",CACR
001826 PRINT USING LYT4 ,                                                !
001828 "MAGNESIUM HARDNESS          (PPM CACO3)     ",MGCR
001830 PRINT USING LYT4 ,                                                !
001832 "M ALKALINITY                (PPM CACO3)     ",MACR
001834 PRINT USING LYT4 ,                                                !
001836 "TOTAL DISSOLVED SOLIDS      (PPM)           ",TDSCR
001838 PRINT USING LYT4 ,                                                !
001840 "SILICA                      (PPM SIO2)      ",SICR
001842 PRINT USING LYT4 ,                                                !
001844 "TOTAL SUSPENDED SOLIDS      (PPM)           ",TSSCR
001846 PRINT
001848 PRINT "*****     DEAERATING HEATER DATA     *****"
001850 PRINT
001852 PRINT USING LYT8 ,                                                !
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001854 "OPERATING TEMPERATURE OF DEAERATING HEATER   (DEG F) = ",TF
001856 PRINT USING LYT8 ,                                          !
001858 "OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG) = ",PDA
001860 PRINT USING LYT8 ,                                          !
001862 "ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL        (FT)  = ",AMSL
001864 PRINT USING LYT11,                                          !
001866 "EFFLUENT OF YOUR 'DEAERATING HEATER'        (PPM O2) = ",OXF
001868 PRINT
001870 PRINT "*****     STEAM PRODUCTION DATA     *****"
001872 PRINT
001874 PRINT USING LYT7 ,                                          !
001876 "OPERATING GAUGE PRESSURE OF BOILER (PSIG)             =    ",PBLR
001878 PRINT USING LYT7 ,                                          !
001880 "RATED STEAM PRODUCTION OF BOILER (POUNDS/HOUR)        =     ",RS
001882 QSM = RS / FE
001884 PRINT USING LYT5 ,                                          !
001886 "MAXIMUM EVAPORATION (POUNDS/HOUR QSM)       =     ",QSM
001888 PRINT USING LYT5 ,                                          !
001890 "EVAPORATION CAPACITY INVESTIGATED (QS)      =     ",QS
001892 PRINT
001894 PRINT "*****     DETERMINE OPERATING CONDITIONS     *****"
001896 PRINT
001898 PRINT USING LYT7 ,                                          !
001900 "ESTIMATED STEAM AND CONDENSATE LOSSES (POUNDS/HOUR QL)  =   ",QL
001902 PRINT USING LYT7 ,                                          !
001904 "CONDENSATE RETURNED (POUNDS/HOUR QCR)                  =   ",QCR
001906 PRINT
001908 PRINT USING LYT5 ,                                          !
001910 "TOTAL DISSOLVED SOLIDS IN STEAM (PPM)       =     ",TDSS
001912 IF TDSS > 0 THEN GOTO 1914    ELSE GOTO 1916
001914 PRINT WARNQS3$
001916 PRINT
001918 PRINT USING LYT5 ,                                          !
001920 "SILICA IN STEAM                             =     ",SIS
001922 IF SIS > 0 THEN GOTO 1924    ELSE GOTO 1926
001924 PRINT WARNQS3$
001926 PRINT
001928 PRINT USING LYT5 ,                                          !
001930 "MAKEUP (POUNDS/HOUR QMU) BASED ON TDS       =     ",QMUTDS
001932 PRINT USING LYT5 ,                                          !
001934 "MAKEUP (POUNDS/HOUR QMU) BASED ON SIO2      =     ",QMUSI
001936 PRINT USING LYT5 ,                                          !
001938 "MAKEUP (POUNDS/HOUR QMU) BASED ON TSS       =     ",QMUTSS
001940 PRINT
001942 IF Z$ ="N" THEN GOTO 1950
001944 PRINT USING LYT5 ,                                          !
001946 "MAKEUP CONSTRAINED TO THE FOLLOWING VALUE (LB/HR) ",QMUC :  !
001948 GOTO 1964
001950 IF QMUTDS >= QMUSI THEN GOTO 1954
001952 IF QMUSI > QMUTDS  THEN GOTO 1960
001954 PRINT USING LYT5 ,                                          !
001956 "MAKEUP LIMITED BY TDS (POUNDS/HOUR QMU)     =     ",QMUTDS
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001958 GOTO 1964
001960 PRINT USING LYT5 ,                                                    !
001962 "MAKEUP LIMITED BY SIO2 (POUNDS/HOUR QMU)    =     ",QMUSI
001964 IF QMUTSS > QMU THEN GOTO 1966     ELSE GOTO 1968
001966 PRINT WARNTSS1$ : PRINT WARNTSS2$ : PRINT WARNTSS3$ : PRINT
001968 PRINT WARNQMU1$ : PRINT
001970 PRINT
001972 PRINT "*****     FEEDWATER QUALITY     *****"
001974 PRINT
001976 PRINT USING LYT5 ,                                                    !
001978 "FEEDWATER (POUNDS/HOUR QF)                  =     ",QF
001980 PRINT : PRINT USING LYT5 ,                                            !
001982 "TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM)   =     ",TDSF
001984 PRINT "   BY CALCULATION"
001986 PRINT USING LYT5 ,                                                    !
001988 "TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM)   =     ",TDSFT
001990 PRINT "   BY TEST"
001992 PRINT : PRINT USING LYT5 ,                                            !
001994 "SILICA IN FEEDWATER          (PPM SIO2)     =     ",SIF
001996 PRINT "   BY CALCULATION"
001998 PRINT USING LYT5 ,                                                    !
002000 "SILICA IN FEEDWATER          (PPM SIO2)     =     ",SIFT
002002 PRINT "   BY TEST"
002004 PRINT : PRINT USING LYT5 ,                                            !
002006 "TOTAL SUSPENDED SOLIDS IN FEEDWATER (PPM)   =     ",TSSF
002008 PRINT "   BY CALCULATION"
002010 PRINT
002012 PRINT "*****     CYCLES OF CONCENTRATION     *****"
002014 PRINT
002016 PRINT USING LYT5 ,                                                    !
002018 "LIMIT SELECTED FOR TOTAL DISSOLVED SOLIDS (PPM) = ",TDSBD
002020 PRINT USING LYT5 ,                                                    !
002022 "LIMIT SELECTED FOR SILICA            (PPM SIO2) = ",SIBD
002024 TSSBD = 0.08 * TDSBD
002026 PRINT USING LYT5 ,                                                    !
002028 "LIMIT SELECTED FOR TOTAL SUSPENDED SOLIDS (PPM) = ",TSSBD
002030 PRINT : PRINT USING LYT5 ,                                            !
002032 "CYCLES BASED ON TDS - DESIGN LIMIT           =     ",CYCTDSD
002034 IF SIFE <= 0 THEN GOTO 2036    ELSE GOTO 2038
002036 PRINT "     BOILER IS NOT SILICA LIMITED!" : GOTO 2042
002038 PRINT USING LYT5 ,                                                    !
002040 "CYCLES BASED ON SILICA - DESIGN LIMIT        =     ",CYCSID
002042 IF TSSFE <= 0 THEN GOTO 2044    ELSE 2046
002044 PRINT "     BOILER IS NOT SUSPENDED SOLIDS LIMITED!" : GOTO 2062
002046 PRINT USING LYT5 ,                                                    !
002048 "CYCLES BASED ON TSS - DESIGN LIMIT           =     ",CYCTSSD
002050 PRINT : PRINT USING LYT5 ,                                            !
002052 "ACTUAL CYCLES BASED ON TDS                =       ",CYCTDSA
002054 PRINT USING LYT5 ,                                                    !
002056 "ACTUAL CYCLES BASED ON SILICA             =       ",CYCSIA
002058 PRINT USING LYT5 ,                                                    !
002060 "ACTUAL CYCLES BASED ON TSS                =       ",CYCTSSA
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002062 PRINT : PRINT USING LYT5 ,                                              !
002064 "OPERATING CYCLES OF CONCENTRATION          =     ",CYC
002066 PRINT : PRINT USING LYT5 ,                                              !
002068 "CALCULATED OPERATING BOILER TDS     (PPM)       = ",BLRTDS
002070 PRINT USING LYT5 ,                                                      !
002072 "CALCULATED OPERATING BOILER SILICA  (PPM SIO2)  = ",BLRSI
002074 PRINT USING LYT5 ,                                                      !
002076 "CALCULATED OPERATING BOILER TSS     (PPM)       = ",BLRTSS
002078 PRINT
002080 PRINT "*****     DETERMINE BLOWDOWN     *****"
002082 PRINT
002084 PRINT USING LYT5 ,                                                      !
002086 "BLOWDOWN (POUNDS/HOUR  QBD)                =     ",QBD
002088 IF PHSW > 0 THEN GOTO 2090   ELSE GOTO 2154
002090 PRINT
002092 PRINT "*****     DETERMINE PHOSPHATE DOSAGE PER DAY     *****"
002094 PRINT
002096 PRINT USING LYT5 ,                                                      !
002098 "CALCULATED FEEDWATER CALCIUM HARDNESS (PPM CACO3)=",CAF
002100 PRINT USING LYT5 ,                                                      !
002102 "FEEDWATER CALCIUM HARDNESS (PPM CACO3) BY TEST   =",CAFT
002104 PRINT : PRINT "PHOSPHATE CHEMICAL USED  ",PHS$
002106 PRINT USING LYT5 ,                                                      !
002108 "PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL      =",PHSPC
002110 PRINT "POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS      !
002112 OF PHOSPHATE CHEMICAL "
002114 PRINT USING LYT3 ,                                                      !
002116 "               =     ",PHSNOH
002118 PRINT
002120 PRINT USING LYT5 ,                                                      !
002122 "RESIDUAL PO4 DESIRED IN BOILER    (PPM PO4)      =",PHSBD
002124 PRINT USING LYT5 ,                                                      !
002126 "POUNDS OF PHOSPHATE CHEMICAL/DAY FOR RESIDUAL    =",PHSWR
002128 PRINT USING LYT5 ,                                                      !
002130 "POUNDS OF PHOSPHATE CHEMICAL/DAY FOR CA HARDNESS =",PHSWCAF
002132 PRINT USING LYT5 ,                                                      !
002134 "TOTAL POUNDS-PHOSPHATE CHEMICAL/DAY-ADVANCED CALC=",PHSW
002136 IF PHSW > 0 THEN GOTO 2138     ELSE GOTO 2154
002138 IF LBPHS > 0 THEN GOTO 2142    ELSE GOTO 2140
002140 IF LBOTHPHS > 0 THEN GOTO 2148    ELSE GOTO 2154
002142 PRINT USING LYT5 ,                                                      !
002144 "ACTUAL DOSAGE OF PHOSPHATE CHEMICAL     (LB/DAY)= ",LBPHS :            !
002146 GOTO 2154
002148 PRINT "ALTERNATE PHOSPHATE CHEMICAL USED   =   ",OTHPHS$
002150 PRINT USING LYT5 ,                                                      !
002152 "ACTUAL DOSAGE OF ALTERNATE PO4 CHEMICAL (LB/DAY)= ",LBOTHPHS
002154 IF PHSW = 0 THEN GOTO 2156    ELSE GOTO 2184
002156 PRINT
002158 PRINT "*****     DETERMINE SODA ASH DOSAGE PER DAY     *****"
002160 PRINT
002162 PRINT USING LYT8 ,                                                      !
002164 "CALCULATED CALCIUM HARDNESS IN FEEDWATER (PPM CACO3)  =",CAF
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002166 PRINT USING LYT8 ,                                                    !
002168 "CALCIUM HARDNESS IN FEEDWATER (PPM CACO3) BY TEST     =",CAFT
002170 IF SODASHW = 0 THEN GOTO 2172    ELSE GOTO 2176
002172 PRINT "SUFFICIENT NATURALLY OCCURRING ALKALINITY AVAILABLE." :    !
002174 GOTO 2184
002176 PRINT WARNPHS1$ : PRINT WARNPHS2$
002178 PRINT "POUNDS/DAY OF PURE SODIUM CARBONATE (SODA ASH) FOR"
002180 PRINT USING LYT5 ,                                                    !
002182 "CALCIUM REACTIONS WITHOUT PHOSPHATE AVAILABLE  =  ",SODASHW
002184 PRINT
002186 PRINT "*****     DETERMINE CAUSTIC SODA DOSAGE PER DAY     *****"
002188 PRINT
002190 IF MABD > 0.2*BLRTDS THEN GOTO 2192    ELSE GOTO 2194
002192 PRINT WARNMA1$ : PRINT WARNMA2$ : PRINT WARNMA3$ : PRINT
002194 PRINT USING LYT5 ,                                                    !
002196 "PURITY (%) OF CAUSTIC SODA USED              =     ",NAOHPC
002198 PRINT USING LYT5 ,                                                    !
002200 "NAOH POUNDS/DAY FOR PO4 HYDROLYSIS-ADVANCED CALC =",NAOHWPH
002202 PRINT USING LYT5 ,                                                    !
002204 "NAOH POUNDS/DAY FOR CALCIUM HYDROXYAPATITE  =     ",NAOHWCAF
002206 PRINT
002208 PRINT USING LYT5 ,                                                    !
002210 "CALCULATED MAGNESIUM HARDNESS IN FEEDWATER  =     ",MGF
002212 PRINT USING LYT5 ,                                                    !
002214 "CALCULATED SILICA IN FEEDWATER              =     ",SIF
002216 PRINT USING LYT5 ,                                                    !
002218 "SILICA IN FEEDWATER BY TEST                 =     ",SIFT
002220 PRINT USING LYT5 ,                                                    !
002222 "SILICA NEEDED FOR MAGNESIUM REACTIONS       =     ",SINHD
002224 PRINT : PRINT USING LYT5 ,                                            !
002226 "NAOH POUNDS/DAY FOR MAGNESIUM HYDROXIDE      =    ",NAOHWMGF1
002228 PRINT USING LYT5 ,                                                    !
002230 "NAOH POUNDS/DAY FOR SERPENTINE (MG+SILICA)   =    ",NAOHWMGF2
002232 PRINT USING LYT5 ,                                                    !
002234 "TOTAL NAOH POUNDS/DAY FOR MAGNESIUM REACTIONS  =  ",NAOHWMGF
002236 PRINT
002238 IF SIF > SINHD THEN GOTO 2240    ELSE GOTO 2242
002240 PRINT WARNF1$ : PRINT : GOTO 2244
002242 PRINT WARNF2$ : PRINT
002244 PRINT USING LYT5 ,                                                    !
002246 "HYDROXYL RESIDUAL DESIRED   (PPM CACO3)     =     ",OHBD
002248 PRINT USING LYT5 ,                                                    !
002250 "HYDROXYL RESIDUAL BY TEST                   =     ",OHBDT
002252 PRINT "BREAKDOWN OF NATURALLY OCCURRING ALKALINITY GIVES"
002254 PRINT USING LYT5 ,                                                    !
002256 "  TOTAL ESTIMATED HYDROXYL ALKALINITY IN BOILER = ",OHT
002258 PRINT WARNOH6$:PRINT WARNOH7$:PRINT WARNOH8$:PRINT WARNOH9$
002260 IF OHD < 0 THEN GOTO 2262    ELSE GOTO 2266
002262 PRINT "THERE IS NO HYDROXYL DEFICIENCY IN ATTAINING THE DESIRED R!
002264 ESIDUAL!" : GOTO 2270
002266 PRINT USING LYT5 ,                                                    !
002268 "HYDROXYL DEFICIENCY         (PPM CACO3)     =     ",OHD
```

```
002270 PRINT : IF OHD < 0 THEN GOTO 2272   ELSE GOTO 2274
002272 PRINT WARNOH1$ : PRINT
002274 IF OHT > 500 THEN GOTO 2276   ELSE GOTO 2278
002276 PRINT WARNOH2$ : PRINT WARNOH3$ : PRINT
002278 PRINT "ESTIMATED REDUCTION IN NAOH (POUNDS/DAY) DUE TO NATURALLY"
002280 PRINT USING LYT5 ,                                                    !
002282 "OCCURRING ALKALINITY                          =     ",DNAOHWR
002284 PRINT USING LYT5 ,                                                    !
002286 "NAOH POUNDS/DAY FOR RESIDUAL                  =     ",NAOHWR
002288 IF NAOHW >= 0 THEN GOTO 2290    ELSE GOTO 2296
002290 PRINT USING LYT5 ,                                                    !
002292 "TOTAL CAUSTIC SODA POUNDS/DAY                 =     ",NAOHW
002294 GOTO 2302
002296 PRINT "* NO CAUSTIC SODA REQUIRED!"
002298 PRINT USING LYT5 ,                                                    !
002300 "  CAN REDUCE EQUIVALENT CAUSTIC SODA POUNDS/DAY BY",NAOHW
002302 IF NAOHW > 0 THEN GOTO 2304     ELSE GOTO 2320
002304 IF LBOH > 0 THEN GOTO 2308    ELSE GOTO 2306
002306 IF LBOTHOH > 0 THEN GOTO 2314    ELSE GOTO 2320
002308 PRINT USING LYT5 ,                                                    !
002310 "ACTUAL DOSAGE OF CAUSTIC SODA           (LB/DAY)= ",LBOH
002312 GOTO 2320
002314 PRINT "ALTERNATE OH ALKALINITY CHEMICAL USED  =  ",OTHOH$
002316 PRINT USING LYT5 ,                                                    !
002318 "ACTUAL DOSAGE OF OH CHEMIC   'SED       (LB/DAY)= ",LBOTHOH
002320 PRINT
002322 PRINT "*****     DETERMINE     )SULFONATE DOSAGE PER DAY    *****"
002324 PRINT
002326 PRINT USING LYT4 ,                                                    !
002328 "RESIDUAL PPM LIGNOSULFO"    DESIRED    =     ",LSNBD
002330 PRINT USING LYT4 ,                                                    !
002332 "PURITY (%) OF LIGNOSULFONATE CHEMICAL  =     ",LSNPC
002334 PRINT USING LYT4 ,                                                    !
002336 "LIGNOSULFONATE DOSAGE FOR RESIDUAL     =     ",LSNWR
002338 PRINT USING LYT5 ,                                                    !
002340 "LIGNOSULFONATE DOSAGE FOR FDWTR 20 % M ALKALINITY=",LSNWMAF
002342 PRINT USING LYT5 ,                                                    !
002344 "LIGNOSULFONATE DOSAGE REQUIRED (POUNDS/DAY)      =",LSNW
002346 IF LSNW > 0 THEN GOTO 2348     ELSE GOTO 2364
002348 IF LBLSN > 0 THEN GOTO 2352    ELSE GOTO 2350
002350 IF LBOTHLSN > 0 THEN GOTO 2358    ELSE GOTO 2364
002352 PRINT USING LYT5 ,                                                    !
002354 "ACTUAL DOSAGE OF LIGNOSULFONATE         (LB/DAY)= ",LBLSN
002356 GOTO 2364
002358 PRINT "ALTERNATE SLUDGE CONDITIONER USED   =   ",OTHLSN$
002360 PRINT USING LYT5 ,                                                    !
002362 "ACTUAL DOSAGE OF SLUDGE CONDITIONER     (LB/DAY)= ",LBOTHLSN
002364 PRINT
002366 PRINT "*****     DETERMINE SULFITE DOSAGE PER DAY     *****"
002368 PRINT
002370 GOSUB DAOPS
002372 PRINT USING LYT4 ,                                                    !
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```
002374 "RESIDUAL SULFITE (PPM SO3) DESIRED     =     ",SFBD
002376 PRINT USING LYT4 ,                                          !
002378 "PURITY (%) OF SULFITE CHEMICAL         =     ",SFPC
002380 PRINT USING LYT4 ,                                          !
002382 "SODIUM SULFITE NEEDED FOR RESIDUAL       =  ",SFWR(N)
002384 PRINT USING LYT4 ,                                          !
002386 "SODIUM SULFITE NEEDED FOR OXYGEN LEAKAGE  =  ",SFWOX(N)
002388 PRINT USING LYT4 ,                                          !
002390 "SODIUM SULFITE REQUIRED (POUNDS/DAY)      =  ",SFW
002392 IF SFW > 0 THEN GOTO 2394     ELSE GOTO 2410
002394 IF LBSF > 0 THEN GOTO 2398    ELSE GOTO 2396
002396 IF LBOTHSF > 0 THEN GOTO 2404    ELSE GOTO 2410
002398 PRINT USING LYT4 ,                                          !
002400 "ACTUAL DOSAGE OF SODIUM SULFITE (LB/DAY)  =  ",LBSF
002402 GOTO 2410
002404 PRINT "ALTERNATE OXYGEN SCAVENGER USED   =    ",OTHSF$
002406 PRINT USING LYT4 ,                                          !
002408 "ACTUAL DOSAGE OF OXYGEN SCAVENGER (LB/DAY)=  ",LBOTHSF
002410 PRINT
002412 PRINT "*****     DETERMINE NEUTRALIZING AMINE DOSAGE     *****"
002414 PRINT "*****           FOR A 50/50 MIXTURE OF            *****"
002416 PRINT "*****        CYCLOHEXYLAMINE AND MORPHOLINE       *****"
002418 PRINT
002420 PRINT USING LYT4 ,                                          !
002422 "P ALKALINITY IN FEEDWATER BY TEST      =     ",PAFT
002424 PRINT USING LYT4 ,                                          !
002426 "CALCULATED M ALKALINITY IN FEEDWATER   =     ",MAF
002428 PRINT USING LYT4 ,                                          !
002430 "M ALKALINITY IN FEEDWATER BY TEST      =     ",MAFT
002432 PRINT
002434 PRINT USING LYT4 ,                                          !
002436 "PER CENT OF CARBONATE ALKALINITY BREAKDOWN  =",CARBPC
002438 PRINT USING LYT4 ,                                          !
002440 "CALCULATED FEEDWATER BICARBONATE ALKALINITY =",BICARBF
002442 PRINT USING LYT4 ,                                          !
002444 "CALCULATED FEEDWATER CARBONATE ALKALINITY   =",CARBF
002446 PRINT USING LYT4 ,                                          !
002448 "EQUIV CARBON DIOXIDE (PPM CO2) IN FEEDWATER =",CDOF
002450 PRINT
002452 PRINT USING LYT4 ,                                          !
002454 "PURITY (%) OF CYCLOHEXYLAMINE USED     =     ",CHAPC
002456 PRINT USING LYT4 ,                                          !
002458 "PURITY (%) OF MORPHOLINE USED          =     ",MORPC
002460 PRINT USING LYT4 ,                                          !
002462 "CYCLOHEXYLAMINE DISTRIBUTION RATIO      =     ",CHADR
002464 PRINT USING LYT4 ,                                          !
002466 "MORPHOLINE DISTRIBUTION RATIO          =     ",MORDR
002468 PRINT USING LYT4 ,                                          !
002470 "CYCLOHEXYLAMINE DOSAGE (LB/DAY)        =     ",CHAW
002472 PRINT USING LYT4 ,                                          !
002474 "MORPHOLINE DOSAGE      (LB/DAY)        =     ",MORW
002476 PRINT WARNNA1$ : PRINT WARNNA2$ : PRINT
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002478 PRINT WARNNA3$ : PRINT WARNNA4$ : PRINT
002480 IF (CHAW > 0 OR MORW > 0) THEN GOTO 2482     ELSE GOTO 2502
002482 IF (LBCHA > 0 OR LBMOR > 0) THEN GOTO 2486    ELSE GOTO 2484
002484 IF LBOTHAM > 0 THEN GOTO 2496    ELSE GOTO 2502
002486 PRINT USING LYT5 ,                                                    !
002488 "ACTUAL DOSAGE OF CYCLOHEXYLAMINE        (LB/DAY)= ",LBCHA
002490 PRINT USING LYT5 ,                                                    !
002492 "ACTUAL DOSAGE OF MORPHOLINE             (LB/DAY)= ",LBMOR
002494 GOTO 2502
002496 PRINT "ALTERNATE NEUTRALIZING AMINE USED   =   ",OTHAM$
002498 PRINT USING LYT5 ,                                                    !
002500 "ACTUAL DOSAGE OF NEUTRALIZING AMINE    (LB/DAY) = ",LBOTHAM
002502 PRINT
002504 PRINT "*****          BOILER QUALITY OF INTEREST          *****"
002506 PRINT "*****    FROM WATER TREATMENT LOG (AF FORM 1459)    *****"
002508 PRINT
002510 PRINT USING LYT4 ,                                                    !
002512 "HYDROXYL ALKALINITY          (PPM CACO3)     ",OHBDT
002514 PRINT USING LYT4 ,                                                    !
002516 "TOTAL DISSOLVED SOLIDS        (PPM)           ",TDSBDT
002518 PRINT USING LYT4 ,                                                    !
002520 "PHOSPHATE                    (PPM PO4)       ",PHSBDT
002522 PRINT USING LYT4 ,                                                    !
002524 "SULFITE                      (PPM SO3)       ",SFBDT
002526 PRINT USING LYT4 ,                                                    !
002528 "LIGNOSULFONATE         (PPM TANNIC ACID)     ",LSNBDT
002530 PRINT USING LYT4 ,                                                    !
002532 "PH                                           ",PHBLR
002534 PRINT
002536 PRINT "TEMPER COMMENTS BELOW IF ALTERNATE CHEMICALS ARE USED VICE!
002538  AFP 91-41 STOCKS." : PRINT
002540 IF (QMU = QMUTDS) OR (QMU = QMUC) THEN GOTO 2542   ELSE GOTO SIO2
002542 IF PBLR >= 0 AND PBLR <=15 THEN GOTO 2544   ELSE GOTO 2548
002544 IF TDSBDT > 6000 THEN PRINT WARNTDS1$
002546 IF TDSBDT < 0.9*6000 THEN PRINT WARNTDS2$
002548 IF PBLR > 15 AND PBLR < 150 THEN GOTO 2550   ELSE GOTO 2554
002550 IF TDSBDT > 4000 THEN PRINT WARNTDS1$
002552 IF TDSBDT < 0.9*4000 THEN PRINT WARNTDS2$
002554 IF PBLR >= 150 AND PBLR < 300 THEN GOTO 2556   ELSE GOTO 2560
002556 IF TDSBDT > 4000 THEN PRINT WARNTDS1$
002558 IF TDSBDT < 0.9*4000 THEN PRINT WARNTDS2$
002560 IF PBLR >= 300 AND PBLR < 450 THEN GOTO 2562   ELSE GOTO 2566
002562 IF TDSBDT > 3500 THEN PRINT WARNTDS1$
002564 IF TDSBDT < 0.9*3500 THEN PRINT WARNTDS2$
002566 IF PBLR >= 450 AND PBLR < 600 THEN GOTO 2568   ELSE GOTO 2572
002568 IF TDSBDT > 3000 THEN PRINT WARNTDS1$
002570 IF TDSBDT < 0.9*3000 THEN PRINT WARNTDS2$
002572 IF PBLR >= 600 AND PBLR < 750 THEN GOTO 2574   ELSE GOTO 2578
002574 IF TDSBDT > 2500 THEN PRINT WARNTDS1$
002576 IF TDSBDT < 0.9*2500 THEN PRINT WARNTDS2$
002578 IF PBLR >= 750 THEN GOTO 2580    ELSE GOTO TOTALSS
002580 IF TDSBDT > 2000 THEN PRINT WARNTDS1$
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002582 IF TDSBDT < 0.9*2000 THEN PRINT WARNTDS2$ : GOTO TOTALSS
002584 SIO2 : IF QMU = QMUSI THEN GOTO 2586    ELSE GOTO TOTALSS
002586 IF TDSBDT > BLRTDS THEN PRINT WARNTDS3$
002588 IF TDSBDT < 0.9*BLRTDS THEN PRINT WARNTDS4$
002590 TOTALSS : PRINT: IF QMUTSS > QMU THEN GOTO 2592    ELSE GOTO 2596
002592 PRINT WARNTSS1$ : PRINT WARNTSS2$ : PRINT WARNTSS3$ : PRINT
002594 IF TDSBDT > BLRTDS THEN PRINT WARNTDS5$ : PRINT
002596 IF PBLR >= 0 AND PBLR <=15 THEN GOTO 2598   ELSE GOTO 2612
002598 IF SIBDT > 200 THEN PRINT WARNSI1$ : PRINT
002600 IF SFBDT > 60 THEN PRINT WARNSF1$
002602 IF SFBDT < 30 THEN PRINT WARNSF2$ : PRINT
002604 IF OHBDT > 550 OR PHBLR > 12.1 THEN PRINT WARNOH4$
002606 IF OHBDT < 300 OR PHBLR < 11.75 THEN PRINT WARNOH5$ : PRINT
002608 IF LSNBDT>100 AND LSNBDT>1.1*0.2*MAFT THEN PRINT WARNLSN1$
002610 IF LSNBDT<70 AND LSNBDT<0.9*0.2*MAFT THEN PRINT WARNLSN2$ : PRINT
002612 IF PBLR > 15 AND PBLR < 150 THEN GOTO 2614   ELSE GOTO 2628
002614 IF SIBDT > 200 THEN PRINT WARNSI1$ : PRINT
002616 IF SFBDT > 60 THEN PRINT WARNSF1$
002618 IF SFBDT < 30 THEN PRINT WARNSF2$ : PRINT
002620 IF OHBDT > 500 OR PHBLR > 12.0 THEN PRINT WARNOH4$
002622 IF OHBDT < 220 OR PHBLR < 11.65 THEN PRINT WARNOH5$ : PRINT
002624 IF LSNBDT>100 AND LSNBDT>1.1*0.2*MAFT THEN PRINT WARNLSN1$
002626 IF LSNBDT<70 AND LSNBDT<0.9*0.2*MAFT THEN PRINT WARNLSN2$ : PRINT
002628 IF PBLR >= 150 AND PBLR < 300 THEN GOTO 2630   ELSE GOTO 2644
002630 IF SIBDT > 150 THEN PRINT WARNSI1$ : PRINT
002632 IF SFBDT > 60 THEN PRINT WARNSF1$
002634 IF SFBDT < 30 THEN PRINT WARNSF2$ : PRINT
002636 IF OHBDT > 500 OR PHBLR > 12.0 THEN PRINT WARNOH4$
002638 IF OHBDT < 220 OR PHBLR < 11.65 THEN PRINT WARNOH5$ : PRINT
002640 IF LSNBDT>100 AND LSNBDT>1.1*0.2*MAFT THEN PRINT WARNLSN1$
002642 IF LSNBDT<70 AND LSNBDT<0.9*0.2*MAFT THEN PRINT WARNLSN2$ : PRINT
002644 IF PBLR >= 300 AND PBLR < 450 THEN GOTO 2646   ELSE GOTO 2660
002646 IF SIBDT > 90 THEN PRINT WARNSI1$ : PRINT
002648 IF SFBDT > 40 THEN PRINT WARNSF1$
002650 IF SFBDT < 20 THEN PRINT WARNSF2$ : PRINT
002652 IF OHBDT > 450 OR PHBLR > 11.95 THEN PRINT WARNOH4$
002654 IF OHBDT < 180 OR PHBLR < 11.55 THEN PRINT WARNOH5$ : PRINT
002656 IF LSNBDT>100 AND LSNBDT>1.1*0.2*MAFT THEN PRINT WARNLSN1$
002658 IF LSNBDT<70 AND LSNBDT<0.9*0.2*MAFT THEN PRINT WARNLSN2$ : PRINT
002660 IF PBLR >= 450 AND PBLR < 600 THEN GOTO 2662   ELSE GOTO 2676
002662 IF SIBDT > 40 THEN PRINT WARNSI1$ : PRINT
002664 IF SFBDT > 40 THEN PRINT WARNSF1$
002666 IF SFBDT < 20 THEN PRINT WARNSF2$ : PRINT
002668 IF OHBDT > 425 OR PHBLR > 11.25 THEN PRINT WARNOH4$
002670 IF OHBDT < 170 OR PHBLR < 11.52 THEN PRINT WARNOH5$ : PRINT
002672 IF LSNBDT>90 AND LSNBDT>1.1*0.2*MAFT THEN PRINT WARNLSN1$
002674 IF LSNBDT<60 AND LSNBDT<0.9*0.2*MAFT THEN PRINT WARNLSN2$ : PRINT
002676 IF PBLR >= 600 AND PBLR < 750 THEN GOTO 2678   ELSE GOTO 2692
002678 IF SIBDT > 30 THEN PRINT WARNSI1$ : PRINT
002680 IF SFBDT > 30 THEN PRINT WARNSF1$
002682 IF SFBDT < 15 THEN PRINT WARNSF2$ : PRINT
002684 IF OHBDT > 425 OR PHBLR > 11.25 THEN PRINT WARNOH4$
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002686 IF OHBDT < 170 OR PHBLR < 11.52 THEN PRINT WARNOH5$ : PRINT
002688 IF LSNBDT>80 AND LSNBDT>1.1*0.2*MAFT THEN PRINT WARNLSN1$
002690 IF LSNBDT<50 AND LSNBDT<0.9*0.2*MAFT THEN PRINT WARNLSN2$ : PRINT
002692 IF PBLR >= 750 THEN GOTO 2694    ELSE 2708
002694 IF SIBDT > 20 THEN PRINT WARNSI1$ : PRINT
002696 IF SFBDT > 30 THEN PRINT WARNSF1$
002698 IF SFBDT < 15 THEN PRINT WARNSF2$ : PRINT
002700 IF OHBDT > 425 OR PHBLR > 11.25 THEN PRINT WARNOH4$
002702 IF OHBDT < 170 OR PHBLR < 11.52 THEN PRINT WARNOH5$ : PRINT
002704 IF LSNBDT>70 AND LSNBDT>1.1*0.2*MAFT THEN PRINT WARNLSN1$
002706 IF LSNBDT<40 AND LSNBDT<0.9*0.2*MAFT THEN PRINT WARNLSN2$ : PRINT
002708 IF PHSW > 0 AND PHSBDT > 60 THEN PRINT WARNPHS3$
002710 IF PHSW > 0 AND PHSBDT < 30 THEN PRINT WARNPHS4$ : PRINT
002712 IF (OHBDT < 50 OR PHBLR < 11) AND PHSW > 0 THEN GOTO 2716    ELSE!
002714 GOTO 2718
002716 PRINT WARNF3$ : PRINT WARNF4$ : PRINT
002718 MABD = OHBDT + ((0.5*BICARBF)+CARBF)*((100-CARBPC)*CYC/100)
002720 IF (MABD > 0.2*BLRTDS) OR (MABD > 0.2*TDSBDT) THEN GOTO 2724     !
002722 ELSE GOTO 2726
002724 PRINT WARNMA1$ : PRINT WARNMA2$ : PRINT WARNMA3$ : PRINT
002726 PRINT
002728 PRINT "***   SUMMARY OF ACTUAL AND CALCULATED CHEMICAL DOSAGES   !
002730 ***" : PRINT
002732 PRINT "ANALYSIS NOTE - IF PURPOSE IS TO MODEL ACTUAL SYSTEM OPERA!
002734 TION, THEN DATA RECORD"
002736 PRINT "SHOULD REFLECT THE OPERATIONAL LIMITS BEING USED FOR EACH !
002738 CHEMICAL OR TEST AND  "
002740 PRINT "THE MAKEUP SHOULD BE CONSTRAINED TO THE ACTUAL METERED MAK!
002742 EUP VALUE.  THIS      "
002744 PRINT "SHOULD RESULT IN BLOWDOWN EQUIVALENCE BETWEEN ACTUAL SYSTE!
002746 M AND CALCULATED      "
002748 PRINT "RESULTS.  THEN COMPARISON OF ACTUAL AND CALCULATED DOSAGES!
002750  IS OF VALUE.  FOR    "
002752 PRINT "EXAMPLE - ACTUAL SULFITE DOSAGE GREATER THAN CALCULATED CO!
002754 ULD INDICATE MORE     "
002756 PRINT "OXYGEN IN THE FEEDWATER THAN ESTIMATED, AN OUT OF CALIBRAT!
002758 ION PRESSURE OR       "
002760 PRINT "TEMPERATURE GAUGE ON THE DEAERATING HEATER, OR A DEFECTIVE!
002762  DEAERATING HEATER.   "
002764 PRINT "SIMILARLY, A HIGH PHOSPHATE DOSAGE CAN INDICATE A MALFUNCT!
002766 IONING SOFTENER OR    "
002768 PRINT "CONDENSATE CONTAMINATED WITH POTABLE WATER CONTAINING HARD!
002770 NESS."
002772 PRINT
002774 IF PHSW > 0 THEN GOTO 2776   ELSE GOTO 2798
002776 IF LBPHS > LBOTHPHS THEN GOTO 2778    ELSE GOTO 2786
002778 PRINT USING LYT9,                                              !
002780 "PHOSPHATE CHEMICAL USED        =       ",PHS$
002782 PRINT USING LYT4,                                              !
002784 "ACTUAL PHOSPHATE DOSAGE (POUNDS/DAY) = ",LBPHS : GOTO 2794
002786 PRINT USING LYT9,                                              !
002788 "ALTERNATE PHOSPHATE CHEMICAL USED   =  ",OTHPHS$
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002790 PRINT USING LYT4,                                                    !
002792 "ACTUAL PHOSPHATE DOSAGE (POUNDS/DAY)  =",LBOTHPHS
002794 PRINT USING LYT4,                                                    !
002796 "CALCULATED PHOSPHATE DOSAGE (LBS/DAY) =",PHSW  : PRINT
002798 IF NAOHW > 0 THEN GOTO 2800   ELSE GOTO 2818
002800 IF LBOH > LBOTHOH THEN GOTO 2802    ELSE GOTO 2806
002802 PRINT USING LYT4,                                                    !
002804 "ACTUAL NAOH DOSAGE (POUNDS/DAY)     =  ",LBOH  : GOTO 2814
002806 PRINT USING LYT9,                                                    !
002808 "ALTERNATE CAUSTIC CHEMICAL USED     =  ",OTHOH$
002810 PRINT USING LYT4,                                                    !
002812 "ACTUAL CAUSTIC DOSAGE (POUNDS/DAY)  =  ",LBOTHOH
002814 PRINT USING LYT4,                                                    !
002816 "CALCULATED NAOH DOSAGE (LBS/DAY)    =  ",NAOHW : PRINT
002818 IF LSNW > 0 THEN GOTO 2820    ELSE GOTO 2838
002820 IF LBLSN > LBOTHLSN THEN GOTO 2822    ELSE GOTO 2826
002822 PRINT USING LYT4,                                                    !
002824 "ACTUAL LIGNOSULFONATE (POUNDS/DAY)  =  ",LBLSN : GOTO 2834
002826 PRINT USING LYT9,                                                    !
002828 "ALTERNATE SLUDGE CONDITIONER USED   =  ",OTHLSN$
002830 PRINT USING LYT4,                                                    !
002832 "ACTUAL SLUDGE CONDITIONER (LBS/DAY) =  ",LBOTHLSN
002834 PRINT USING LYT4,                                                    !
002836 "CALCULATED LIGNOSULFONATE (LBS/DAY) =  ",LSNW : PRINT
002838 IF SFW > 0 THEN GOTO 2840   ELSE GOTO 2858
002840 IF LBSF > LBOTHSF THEN GOTO 2842    ELSE GOTO 2846
002842 PRINT USING LYT4,                                                    !
002844 "ACTUAL SODIUM SULFITE (POUNDS/DAY)  =  ",LBSF : GOTO 2854
002846 PRINT USING LYT9,                                                    !
002848 "ALTERNATE OXYGEN SCAVENGER USED     =  ",OTHSF$
002850 PRINT USING LYT4,                                                    !
002852 "ACTUAL OXYGEN SCAVENGER (LBS/DAY)   =  ",LBOTHSF
002854 PRINT USING LYT4,                                                    !
002856 "CALCULATED SODIUM SULFITE (LBS/DAY) =  ",SFW : PRINT
002858 IF (CHAW + MORW) > 0 THEN GOTO 2860   ELSE GOTO 2886
002860 IF (LBCHA + LBMOR) > LBOTHAM THEN GOTO 2862    ELSE GOTO 2870
002862 PRINT USING LYT4,                                                    !
002864 "ACTUAL CYCLOHEXYLAMINE (POUNDS/DAY) =  ",LBCHA
002866 PRINT USING LYT4,                                                    !
002868 "ACTUAL MORPHOLINE      (POUNDS/DAY) =  ",LBMOR : GOTO 2878
002870 PRINT USING LYT9,                                                    !
002872 "ALTERNATE NEUTRALIZING AMINE USED   =  ",OTHAM$
002874 PRINT USING LYT4,                                                    !
002876 "ACTUAL NEUTRALIZING AMINE (LBS/DAY) =  ",LBOTHAM
002878 PRINT USING LYT4,                                                    !
002880 "CALCULATED CYCLOHEXYLAMINE (LBS/DAY) = ",CHAW
002882 PRINT USING LYT4,                                                    !
002884 "CALCULATED MORPHOLINE      (LBS/DAY) = ",MORW : PRINT
002886 PRINT "RUN THE BASIC ANALYSIS CALCULATIONS TO RECEIVE INTERPRETAT!
002888 ION OF THE "
002890 PRINT "SYSTEM OPERATION DATA AND AN INITIAL CALCULATION OF CHEMIC!
002892 AL DOSAGES PER"
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002894 PRINT "AFP 91-41.  NOTE THAT AFP 91-41 ASSUMES NO STEAM OR CONDEN!
002896 SATE LOSSES AND"
002898 PRINT "ESTIMATES DAILY DOSAGES AT A HIGH LEVEL DUE TO USE OF A CY!
002900 CLE OF CONCENTRATION"
002902 PRINT "THAT DOES NOT TAKE INTO ACCOUNT THE CHEMICALS ADDED."
002904 CLOSE PRINTER : SELECT WS : GOTO EXIT1
```

Appendix Four

CALL SUBROUTINE FOR ENTHALPY

```
000010 SUB "ENTHALPY"
000012 *****  SUBROUTINE TO DETERMINE ENTHALPY OF SATURATED VAPOR
000014 *         (HG) KNOWING GAUGE PRESSURE OF BOILER
000016 COM AMSL,HG,PAB,PATM,PBLR,UID$ 3,IPLVOL$ 6,DEEDATAVOL$ 6
000018 LYT5 : FMT CH(50), PIC(#,###,##0.##)
000020 PATM = 14.696 - 0.00032416 * AMSL
000022 PAB = PBLR + PATM
000024 FOR PABT = 0 TO 780 STEP 5
000026 IF PABT <= PAB THEN PABL = PABT
000028 NEXT PABT
000030 PABT = PABL
000032 GOSUB HGTABLE
000034 HGL = HG
000036 FOR PABT = 0 TO 780 STEP 5
000038 IF PABT <= PAB THEN PABH = PABT + 5
000040 NEXT PABT
000042 PABT = PABH
000044 GOSUB HGTABLE
000046 HGH = HG
000048 HG = ((HGH - HGL) * (PAB - PABL) / (PABH - PABL)) + HGL
000050 PRINT : PRINT USING LYT5 ,                                    !
000052 "BOILER OPERATING PRESSURE (PSIG)          =    ",PBLR
000054 PRINT USING  LYT5 ,                                          !
000056 "ALTITUDE ABOVE MEAN SEA LEVEL (FT)        =    ",AMSL
000058 PRINT USING  LYT5 ,                                          !
000060 "ATMOSPHERIC PRESSURE (PSI)               =    ",PATM
000062 PRINT USING  LYT5 ,                                          !
000064 "ABSOLUTE PRESSURE (PSIA)                 =    ",PAB
000066 PRINT : PRINT USING LYT5 ,                                   !
000068 "ENTHALPY OF SATURATED VAPOR (HG)          =    ",HG
000070 END : REM SUBROUTINE ENTHALPY ENDS
000072 *
000074 HGTABLE:
000076 *
000078 IF PABT = 0  THEN HG = 1075.4
000080 IF PABT = 5  THEN HG = 1131.0
000082 IF PABT = 10 THEN HG = 1143.3
000084 IF PABT = 15 THEN HG = 1150.9
000086 IF PABT = 20 THEN HG = 1156.4
```

```
000088 IF PABT = 25 THEN HG = 1160.7
000090 IF PABT = 30 THEN HG = 1164.3
000092 IF PABT = 35 THEN HG = 1167.4
000094 IF PABT = 40 THEN HG = 1170.0
000096 IF PABT = 45 THEN HG = 1172.3
000098 IF PABT = 50 THEN HG = 1174.4
000100 IF PABT = 55 THEN HG = 1176.3
000102 IF PABT = 60 THEN HG = 1178.0
000104 IF PABT = 65 THEN HG = 1179.6
000106 IF PABT = 70 THEN HG = 1181.0
000108 IF PABT = 75 THEN HG = 1182.4
000110 IF PABT = 80 THEN HG = 1183.6
000112 IF PABT = 85 THEN HG = 1184.8
000114 IF PABT = 90 THEN HG = 1185.9
000116 IF PABT = 95 THEN HG = 1186.9
000118 IF PABT = 100 THEN HG = 1187.8
000120 IF PABT = 105 THEN HG = 1188.7
000122 IF PABT = 110 THEN HG = 1189.6
000124 IF PABT = 115 THEN HG = 1190.4
000126 IF PABT = 120 THEN HG = 1191.1
000128 IF PABT = 125 THEN HG = 1191.8
000130 IF PABT = 130 THEN HG = 1192.5
000132 IF PABT = 135 THEN HG = 1193.2
000134 IF PABT = 140 THEN HG = 1193.8
000136 IF PABT = 145 THEN HG = 1194.4
000138 IF PABT = 150 THEN HG = 1194.9
000140 IF PABT = 155 THEN HG = 1195.5
000142 IF PABT = 160 THEN HG = 1196.0
000144 IF PABT = 165 THEN HG = 1196.5
000146 IF PABT = 170 THEN HG = 1196.9
000148 IF PABT = 175 THEN HG = 1197.4
000150 IF PABT = 180 THEN HG = 1197.8
000152 IF PABT = 185 THEN HG = 1198.2
000154 IF PABT = 190 THEN HG = 1198.6
000156 IF PABT = 195 THEN HG = 1199.0
000158 IF PABT = 200 THEN HG = 1199.3
000160 IF PABT = 205 THEN HG = 1199.6
000162 IF PABT = 210 THEN HG = 1200.0
000164 IF PABT = 215 THEN HG = 1200.3
000166 IF PABT = 220 THEN HG = 1200.6
000168 IF PABT = 225 THEN HG = 1200.8
000170 IF PABT = 230 THEN HG = 1201.1
000172 IF PABT = 235 THEN HG = 1201.4
000174 IF PABT = 240 THEN HG = 1201.6
000176 IF PABT = 245 THEN HG = 1201.9
000178 IF PABT = 250 THEN HG = 1202.1
000180 IF PABT = 255 THEN HG = 1202.3
000182 IF PABT = 260 THEN HG = 1202.5
000184 IF PABT = 265 THEN HG = 1202.7
000186 IF PABT = 270 THEN HG = 1202.9
000188 IF PABT = 275 THEN HG = 1203.1
000190 IF PABT = 280 THEN HG = 1203.3
```

```
000192 IF PABT = 285 THEN HG = 1203.4
000194 IF PABT = 290 THEN HG = 1203.6
000196 IF PABT = 295 THEN HG = 1203.7
000198 IF PABT = 300 THEN HG = 1203.9
000200 IF PABT = 305 THEN HG = 1204.0
000202 IF PABT = 310 THEN HG = 1204.1
000204 IF PABT = 315 THEN HG = 1204.3
000206 IF PABT = 320 THEN HG = 1204.4
000208 IF PABT = 325 THEN HG = 1204.5
000210 IF PABT = 330 THEN HG = 1204.6
000212 IF PABT = 335 THEN HG = 1204.7
000214 IF PABT = 340 THEN HG = 1204.8
000216 IF PABT = 345 THEN HG = 1204.9
000218 IF PABT = 350 THEN HG = 1204.9
000220 IF PABT = 355 THEN HG = 1205.0
000222 IF PABT = 360 THEN HG = 1205.1
000224 IF PABT = 365 THEN HG = 1205.2
000226 IF PABT = 370 THEN HG = 1205.2
000228 IF PABT = 375 THEN HG = 1205.3
000230 IF PABT = 380 THEN HG = 1205.3
000232 IF PABT = 385 THEN HG = 1205.4
000234 IF PABT = 390 THEN HG = 1205.4
000236 IF PABT = 395 THEN HG = 1205.5
000238 IF PABT = 400 THEN HG = 1205.5
000240 IF PABT = 405 THEN HG = 1205.5
000242 IF PABT = 410 THEN HG = 1205.5
000244 IF PABT = 415 THEN HG = 1205.5
000246 IF PABT = 420 THEN HG = 1205.5
000248 IF PABT = 425 THEN HG = 1205.6
000250 IF PABT = 430 THEN HG = 1205.6
000252 IF PABT = 435 THEN HG = 1205.6
000254 IF PABT = 440 THEN HG = 1205.6
000256 IF PABT = 445 THEN HG = 1205.6
000258 IF PABT = 450 THEN HG = 1205.6
000260 IF PABT = 455 THEN HG = 1205.6
000262 IF PABT = 460 THEN HG = 1205.5
000264 IF PABT = 465 THEN HG = 1205.5
000266 IF PABT = 470 THEN HG = 1205.5
000268 IF PABT = 475 THEN HG = 1205.5
000270 IF PABT = 480 THEN HG = 1205.5
000272 IF PABT = 485 THEN HG = 1205.5
000274 IF PABT = 490 THEN HG = 1205.4
000276 IF PABT = 495 THEN HG = 1205.4
000278 IF PABT = 500 THEN HG = 1205.3
000280 IF PABT = 505 THEN HG = 1205.3
000282 IF PABT = 510 THEN HG = 1205.2
000284 IF PABT = 520 THEN HG = 1205.2
000286 IF PABT = 525 THEN HG = 1205.2
000288 IF PABT = 530 THEN HG = 1205.1
000290 IF PABT = 535 THEN HG = 1205.0
000292 IF PABT = 540 THEN HG = 1204.9
000294 IF PABT = 545 THEN HG = 1204.9
```

```
000296 IF PABT = 550 THEN HG = 1204.8
000298 IF PABT = 555 THEN HG = 1204.8
000300 IF PABT = 560 THEN HG = 1204.7
000302 IF PABT = 565 THEN HG = 1204.6
000304 IF PABT = 570 THEN HG = 1204.5
000306 IF PABT = 575 THEN HG = 1204.5
000308 IF PABT = 580 THEN HG = 1204.4
000310 IF PABT = 585 THEN HG = 1204.3
000312 IF PABT = 590 THEN HG = 1204.2
000314 IF PABT = 595 THEN HG = 1204.2
000316 IF PABT = 600 THEN HG = 1204.1
000318 IF PABT = 605 THEN HG = 1204.0
000320 IF PABT = 610 THEN HG = 1203.9
000322 IF PABT = 615 THEN HG = 1203.8
000324 IF PABT = 620 THEN HG = 1203.7
000326 IF PABT = 625 THEN HG = 1203.6
000328 IF PABT = 630 THEN HG = 1203.5
000330 IF PABT = 635 THEN HG = 1203.4
000332 IF PABT = 640 THEN HG = 1203.3
000334 IF PABT = 645 THEN HG = 1203.2
000336 IF PABT = 650 THEN HG = 1203.1
000338 IF PABT = 655 THEN HG = 1203.0
000340 IF PABT = 660 THEN HG = 1202.9
000342 IF PABT = 665 THEN HG = 1202.8
000344 IF PABT = 670 THEN HG = 1202.7
000346 IF PABT = 675 THEN HG = 1202.6
000348 IF PABT = 680 THEN HG = 1202.5
000350 IF PABT = 685 THEN HG = 1202.4
000352 IF PABT = 690 THEN HG = 1202.3
000354 IF PABT = 695 THEN HG = 1202.2
000356 IF PABT = 700 THEN HG = 1202.0
000358 IF PABT = 705 THEN HG = 1201.9
000360 IF PABT = 710 THEN HG = 1201.8
000362 IF PABT = 715 THEN HG = 1201.7
000364 IF PABT = 720 THEN HG = 1201.5
000366 IF PABT = 725 THEN HG = 1201.4
000368 IF PABT = 730 THEN HG = 1201.3
000370 IF PABT = 735 THEN HG = 1201.2
000372 IF PABT = 740 THEN HG = 1201.0
000374 IF PABT = 745 THEN HG = 1200.9
000376 IF PABT = 750 THEN HG = 1200.7
000378 IF PABT = 755 THEN HG = 1200.6
000380 IF PABT = 760 THEN HG = 1200.4
000382 IF PABT = 765 THEN HG = 1200.3
000384 IF PABT = 770 THEN HG = 1200.2
000386 IF PABT = 775 THEN HG = 1200.1
000388 IF PABT = 780 THEN HG = 1199.9
000390 RETURN : REM SUBROUTINE HGTABLE ENDS
```

Appendix Five

SAMPLE SCREENS TO
CREATE A FILE RECORD

Note - A single row of asterisks (*) or new pages separate the screens. The screens are in order of occurrence and minimal data is shown.

```
**********************************************************
**       STEAM BOILER WATER TREATMENT PROGRAM           **
**                                                      **
**     WRITTEN BY MAJOR MICHAEL J.W. KAMINSKAS          **
**          AIR COMMAND AND STAFF COLLEGE               **
**              MAXWELL AFB AL 36112                    **
**                  FEBRUARY 1988                       **
**   DIRECT COMMENTS TO HQ AFESC/DEMM AV 523-6351       **
**                   OR AFIT/DEE      AV 785-4552       **
**********************************************************

 ENTER     FOR ACTION
 -----     ----------
   1       BOILER AND TREATMENT DATA FILE
   3       AFP 91-41 DOSAGE CALCULATIONS AND
             BASIC SYSTEM AND TREATMENT ANALYSIS
   5       ESTIMATED TREATMENT STABILITY POINT AND
             ADVANCED TREATMENT ANALYSIS
  16       EXIT FROM PROGRAM

    ACTION NUMBER *1
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

 BOILER AND TREATMENT DATA FILE
 ENTER     FOR ACTION
 -----     ----------
   1       CREATE NEW DATA RECORD
   3       UPDATE EXISTING DATA RECORD
   5       DELETE EXISTING DATA RECORD
  16       RETURN TO PREVIOUS MENU



  21       CREATE NEW DATA FILE - RUN ONLY ONCE

    ACTION NUMBER *1

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

THIS SCREEN ASKS FOR A RECORD NAME (KEYFIELD) TO DESIGNATE THE DATA RECORD
  BEING CREATED.  ALL DATA REQUESTED IS NEEDED TO UNIQUELY DESCRIBE THIS
RECORD.

    COMPUTER USER ID  (EG. I1K)   I1K
    TODAY'S DATE      (YYMMDD)    880201
    BASE ID           (EG. MAX)   ***
    BUILDING NUMBER   (EG. 1402)  *******
    BOILER DESIGNATOR (EG. 4)     **
    RUN INDICATOR                 **
      (EG. A=ACTUAL CONDITIONS, I=IDEAL CONDITIONS,
           S=SOFTENER, LL=LOW LOSS, PC=PURE CONDENSATE)

PRESS <ENTER> TO CONTINUE

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

    INSTALLATION (EG. XXXX AFB)    ********************
    LAST NAME    (EG. YOURS)       ***************
COMMENT DESCRIBING THIS DATA   ***********************************************


**    NOTE - IF EXITING, ALL DATA ENTERED TO THAT POINT WILL BE SAVED!    **

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?
```

STEAM BOILER WATER TREATMENT PROGRAM

```
************************
*       WARNING        *
*  DO NOT USE COMMAS   *
* IN NUMERICAL INPUTS  *
************************
```

NOTE - CONDUCTIVITY IS NOT AN INPUT ANYWHERE IN THIS PROGRAM. THE RELATIONSHIP BETWEEN CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IS NOT A FIXED RATIO. AFP 91-41 DOES USE AN APPROXIMATION HOWEVER. HIGHLY RECOMMEND SAMPLES BE TESTED FOR CONDUCTIVITY, TOTAL DISSOLVED SOLIDS, AND TOTAL SUSPENDED SOLIDS TWICE A YEAR. THE BASE FUELS LAB CAN PERFORM THE LATTER TWO TESTS. THEN DETERMINE THE TOTAL DISSOLVED SOLIDS/CONDUCTIVITY RATIO FOR EACH SAMPLE. ONCE THE RATIO IS FOUND THE BOILER CAN BE OPERATED ON A CONDUCTIVITY LIMIT THAT RELATES TO THE TOTAL DISSOLVED SOLIDS LIMIT WITH GREAT CONFIDENCE. THE SAMPLE USED MUST BE AS CLOSE AS POSSIBLE TO THE FINAL OPERATING POINT. ADJUST TREATMENT AND RERUN THESE TESTS UNTIL THE DESIRED OPERATING POINT IS REACHED.

PRESS <ENTER> TO CONTINUE

****

STEAM BOILER WATER TREATMENT PROGRAM

OTHER SOURCES OF THE DATA NEEDED FOR THIS PROGRAM ARE AS FOLLOWS:

MAKEUP WATER QUALITY - AF FORM 2752, ENVIRONMENTAL SAMPLING DATA
  HOSPITAL BIOENVIRONMENTAL ENGINEER
  CE ENVIRONMENTAL SUPPORT SHOP (WATER + WASTE)
  LOCAL WATER UTILITY - DIFFERENT FORM
  AFESC CORROSION ANALYSIS REPORT - DIFFERENT FORM
SYSTEM OPERATION - AF FORM 1464, MONTHLY STEAM BOILER PLANT OPERATING LOG
  HEAT SHOP OR CENTRAL HEATING PLANT AS APPROPRIATE
BOILER WATER TESTS - AF FORM 1459, WATER TREATMENT OPERATING LOG FOR STEAM AND HOT WATER BOILERS
  HEAT SHOP OR CENTRAL HEATING PLANT AS APPROPRIATE

THE BASE FUELS LAB IS THE ONLY FUNCTION ON BASE THAT CAN READILY PERFORM THE THE TOTAL DISSOLVED SOLIDS AND TOTAL SUSPENDED SOLIDS TESTS!

ALL OTHER TESTS CAN BE PERFORMED WITH EQUIPMENT AND REAGENTS AVAILABLE UNDER THE AFESC CENTRAL LABORATORY CONTRACT. THESE ITEMS ARE FREE TO ANY BASE UPON REQUEST.

PRESS <ENTER> TO CONTINUE

STEAM BOILER WATER TREATMENT PROGRAM

FOR ACCURATE TESTING, ACCURATE SAMPLING MUST BE DONE!

THE FOLLOWING RULES WILL ENSURE A GOOD START.

1. REVIEW PARA. 6-6, METHODS OF SAMPLING, IN AFP 91-41.
2. ALWAYS USE A SAMPLE COOLER WHENEVER THE SOURCE IS AT PRESSURE AND OVER 100 DEGREES FAHRENHEIT.
3. FILL SAMPLING CONTAINER ABOUT 1/8TH FULL OR LESS AND CAP. AGITATE WELL AND DRAIN. REPEAT TWO TIMES TO FULLY PREPARE THE CONTAINER.
4. DO NOT USE A SAMPLING CONTAINER CONTAMINATED OR CONTAINING ANY ITEM TO BE TESTED. THAT IS, NO GLASS IF SILICA IS BEING TESTED OR COPPER IF COPPER IS OF INTEREST. FOR MOST TESTING PLASTIC IS BEST.
5. RUN THE SAMPLE WATER LONG ENOUGH TO FLUSH THE SAMPLING LINE AND COOLER AND GET A REPRESENTATIVE SAMPLE FROM THE SOURCE.
6. EXTEND THE SAMPLE LINE TO THE BOTTOM OF THE SAMPLE CONTAINER USING PLASTIC TUBING, PREFERABLY TYGON. RUN THE SAMPLE TO OVERFLOW THE SAMPLE CONTAINER AT LEAST TWO CONTAINER VOLUMES AND CAP.

PRESS <ENTER> TO CONTINUE

****

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

** STEAM PRODUCTION DATA **

*** THIS PROGRAM IS DESIGNED FOR USE WITH A ***
SINGLE BOILER. IF ANALYZING A MULTIBOILER PLANT,
PROPORTION THE TOTAL PLANT MASSFLOW TO JUST ONE
BOILER. THUS, ANALYZE EACH BOILER SEPARATELY.
***

OPERATING GAUGE PRESSURE OF BOILER = ***0.00

RATED STEAM PRODUCTION (POUNDS/HOUR) OF BOILER = ******0.00

ACTUAL STEAM PRODUCTION INVESTIGATED (POUNDS/HOUR QS) = 1.00

ESTIMATED LOSSES STEAM AND CONDENSATE (POUNDS/HOUR QL) = ******0.00
NOTE THAT GOOD PRACTICE IS TO KEEP QL AS SMALL AS POSSIBLE BASED UPON STEAM USE!
ALSO NOTE - AFP 91-41 ASSUMES NO LOSSES IN ITS CALCULATIONS!

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ? Y

DO YOU KNOW ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL (Y OR N) ?

ALTITUDE FOR LISTED INSTALLATIONS
FEET ABOVE MEAN SEA LEVEL

ALTUS AFB OK	1376	EGLIN AFB FL	85
ANDERSEN AFB GUAM	525	EIELSON AFB AK	534
ANDREWS AFB MD	279	ELLSWORTH AFB SD	3200
ARNOLD AFS TN	950-1150	ELMENDORF AFB AK	118
BARKSDALE AFB LA	166	ENGLAND AFB LA	89
BEALE AFB CA	113	FAIRCHILD AFB WA	2462
BERGSTROM AFB TX	541	F.E. WARREN AFB WY	6142
BLYTHEVILLE AFB AR	254	GEORGE AFB CA	2875
BOLLING AFB DC	16	GOODFELLOW AFB TX	1877
BROOKS AFB TX	600	GRAND FORKS AFB ND	911
CANNON AFB NM	4295	GRIFFISS AFB NY	504
CARSWELL AFB TX	650	GRISSOM AFB IN	800
CASTLE AFB CA	188	GUNTER AFS AL	220
CHANUTE AFB IL	735	HANSCOM AFB MA	133
CHARLESTON AFB SC	45	HICKAM AFB HI	0
COLUMBUS AFB MS	214	HILL AFB UT	4788
DAVIS-MONTHAN AFB AZ	2620	HOLLOMAN AFB NM	4093
DOVER AFB DE	28	HOMESTEAD AFB FL	7
DYESS AFB TX	1789	HURLBURT FLD FL	35
EDWARDS AFB CA	2302	INDIAN SPRINGS FLD NV	3124

IS YOUR BASE LISTED ABOVE (Y OR N) Q

****

KEESLER AFB MS	26	MOODY AFB GA	233
KELLY AFB TX	689	MOUNTAIN HOME AFB ID	3000
KIRTLAND AFB NM	5352	MYRTLE BEACH AFB SC	25
K.I. SAWYER AFB MI	1220	NELLIS AFB NV	2171
LACKLAND AFB TX	787	NORTON AFB CA	1156
LANGLEY AFB VA	10	OFFUTT AFB NE	1048
LAUGHLIN AFB TX	1080	PATRICK AFB FL	9
LITTLE ROCK AFB AR	310	PEASE AFB NH	101
LORING AFB ME	746	PETERSON AFB CO	6200
LOS ANGELES AFS CA	95	PLATTSBURGH AFB NY	235
LOWRY AFB CO	5400	POPE AFB NC	218
LUKE AFB AZ	1101	RANDOLPH AFB TX	761
MACDILL AFB FL	6	REESE AFB TX	3338
MALMSTROM AFB MT	3525	ROBINS AFB GA	294
MARCH AFB CA	1530	SCOTT AFB IL	453
MATHER AFB CA	96	SEYMOUR JOHNSON AFB NC	109
MAXWELL AFB AL	168	SHAW AFB SC	244
MCCHORD AFB WA	322	SHEMYA AFB AK	270
MCCLELLAN AFB CA	76	SHEPPARD AFB TX	1015
MCCONNELL AFB KS	1371	TINKER AFB OK	1291
MCGUIRE AFB NJ	133	TRAVIS AFB CA	62
MINOT AFB ND	1650	TYNDALL AFB FL	18

IS YOUR BASE LISTED ABOVE (Y OR N) Q

```
    US AIR FORCE ACADEMY 7280  WHITEMAN AFB MO        869
    VANCE AFB OK         1307  WILLIAMS AFB AZ       1385
    VANDENBERG AFB CA     400  WRIGHT-PATTERSON AFB   824
    WHEELER AFB HI        845  WURTSMITH AFB MI       634

                  THIS IS THE LAST LIST!

WOULD YOU LIKE TO RERUN THE LIST ( Y OR N )  N

ALTITUDE (EITHER ABOVE OR BEST GUESS) =? 0

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                   STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

              **      DEAERATING HEATER DATA      **

OPERATING TEMPERATURE OF DEAERATING HEATER (DEG F)      = *212.00
OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG)    = ***0.00

 * DESIGN LIMITATION - MECHANICAL LEAKAGE OF OXYGEN *
                                        DESIGN EFFLUENT
                                             OXYGEN
    TYPE              PSIG     TEMP(F)      (PPM 02)
 OPEN HEATER           0       160-210      0.5-1.0
 DEAERATING HEATER    1-15     215-250        0.04
 DEAERATOR            1-15     215-250        0.007

OXYGEN (PPM 02) IN 'DEAERATING HEATER' EFFLUENT =     .0070

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                   STEAM BOILER WATER TREATMENT PROGRAM

INDICATE  A 'Y' FOR ALL PRETREATMENT THAT APPLIES
          PRESS <ENTER> WHEN DONE

    FILTER                          *
    SODIUM ZEOLITE SOFTENER         *
    HYDROGEN ZEOLITE SOFTENER       *
    SPLIT STREAM SOFTENING          *
    ZEOLITE DEALKALIZER             *
    COLD LIME-SODA SOFTENER         *
    HOT LIME-SODA SOFTENER          *
    DEGASIFIER                      *
     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

 **      MAKEUP WATER QUALITY OF INTEREST      **
 **           AFTER ALL PRETREATMENT           **

   A * IN FRONT OF THE ITEM INDICATES IT AS A
     REGULAR TEST PERFORMED PER AFP 91-41

      TOTAL HARDNESS          (PPM CACO3)  ***0.00
    * CALCIUM HARDNESS        (PPM CACO3)  ***0.00
      MAGNESIUM HARDNESS      (PPM CACO3)  ***0.00
    * M ALKALINITY            (PPM CACO3)  ***0.00
    * TOTAL DISSOLVED SOLIDS  (PPM)        ***0.00
      SILICA                  (PPM SIO2)   ***0.00
      TOTAL SUSPENDED SOLIDS  (PPM)        ***0.00

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

    **      CONDENSATE RETURN QUALITY OF INTEREST      **

 ANALYSIS CAN CONTINUE EITHER
  THEORETICALLY (BY USING PPM INDICATED AS GOOD QUALITY)
         OR
  PRACTICALLY (BY USING ACTUAL CONDENSATE RESULTS)

  RECOMMEND A RECORD WITH IDEAL SYSTEM CHARACTERISTICS
    AND A RECORD WITH ACTUAL SYSTEM CHARACTERISTICS TO
    COMPARE RESULTS AND SEEK ENERGY CONSERVATION AND COST
    SAVINGS.  CREATE RECORDS BY CHANGING ANY INPUT AND COMPARE THE RESULTS!

 ALL SELECTIONS GO INTO DATA RECORDS FOR FUTURE CALCULATIONS


PRESS <ENTER> TO CONTINUE
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

    **      CONDENSATE RETURN QUALITY OF INTEREST      **

  A * IN FRONT OF THE ITEM INDICATES IT AS A
     REGULAR TEST PERFORMED PER AFP 91-41
  THE NUMBER IN ( ) IS A GOOD THEORETICAL GUESS FOR
     PPM OF THAT ITEM IN GOOD QUALITY CONDENSATE.

       TOTAL HARDNESS           (0)(PPM CACO3)  ***0.00
     * CALCIUM HARDNESS         (0)(PPM CACO3)  ***0.00
       MAGNESIUM HARDNESS       (0)(PPM CACO3)  ***0.00
       M ALKALINITY            (15)(PPM CACO3)  ***0.00
     * TOTAL DISSOLVED SOLIDS (15)(PPM)         ***0.00
       SILICA                    (0)(PPM SIO2)  ***0.00
       TOTAL SUSPENDED SOLIDS   (0)(PPM)        ***0.00
     * PH                     (7.5)                7.50
     * IRON                     (0)(PPM FE)     ***0.00
     * COPPER                   (0)(PPM CU)     ***0.00

      ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

    **      FEEDWATER QUALITY OF INTEREST      **

   A * IN FRONT OF THE ITEM INDICATES IT AS A
            TEST NEEDED PER AFP 91-41

     * CALCIUM HARDNESS        (PPM CACO3)  ***0.00
     * M ALKALINITY            (PPM CACO3)  ***0.00
     * P ALKALINITY            (PPM CACO3)  ***0.00
     * TOTAL DISSOLVED SOLIDS (PPM)         ***0.00
     * SILICA                  (PPM SIO2)   ***0.00

      ABOVE DATA CORRECT ( Y OR N ) OR (E)XI   ?
```

STEAM BOILER WATER TREATMENT PROGRAM

MASSFLOW CALCULATIONS INDICATE THAT MOST WATER CONSTITUENTS WILL MIX WELL WHEN THE MAKEUP AND CONDENSATE FLOWS CONVERGE IN THE DEAERATING HEATER.

THUS, MOST CONSTITUENT LEVELS CAN BE CALCULATED IN FEEDWATER USING MAKEUP AND CONDENSATE VALUES.

USING P ALKALINITY TO COMPUTE FEEDWATER LEVELS IS TOO COMPLEX TO DO BY SIMPLE CALCULATION BASED UPON MASSFLOW. THE PH, CO2, ALKALINITY RELATIONSHIP CHANGES AS THE FEEDWATER GOES THROUGH THE DEAERATING HEATER.

NOTE HOWEVER THAT THE M ALKALINITY RELATIONSHIP TO MASSFLOW DOES SEEM TO HOLD.

PRESS <ENTER> TO CONTINUE

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

** BOILER QUALITY OF INTEREST **

A * IN FRONT OF THE ITEM INDICATES IT IS NEEDED PER AFP 91-41

INPUT VALUES TESTED FROM THE WATER TREATMENT LOG (AF FORM 1459)

* HYDROXYL ALKALINITY	(PPM CACO3)	***0.00
* TOTAL DISSOLVED SOLIDS	(PPM)	***0.00
* PHOSPHATE	(PPM PO4)	***0.00
* SULFITE	(PPM SO3)	***0.00
* LIGNOSULFONATE	(PPM TANNIC ACID)	***0.00
* PH	(PPM)	***0.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

** STEAM QUALITY OF INTEREST **

TOTAL DISSOLVED SOLIDS IN STEAM (ASSUME 0 IF PURE) = ***0.00

SILICA IN STEAM (ASSUME 0 IF PURE) = ***0.00

RECOMMEND MEASUREMENT OF STEAM PURITY TWICE A YEAR.
TAKE STEAM SAMPLE AT FIRST HIGH PRESSURE DRIP COMING OFF BOILER. THERE ARE MANY REASONS FOR STEAM NOT TO BE PURE. ACCEPTED GOOD PRACTICE IS TO HAVE PURE STEAM. IF TESTING INDICATES POOR STEAM QUALITY, CHECK STEAM SEPARATORS, BOILER WATER LEVEL, OIL IN FEEDWATER, OVERSTEAMING, AND TOTAL DISSOLVED SOLIDS LEVEL IN BOILER. IF ALL EQUIPMENT AND OPERATION IS PROPER WITHOUT OIL CONTAMINATION OR OTHER REASON FOR FOAMING, REDUCE TOTAL DISSOLVED SOLIDS LEVEL UNTIL STEAM BECOMES PURE. THIS LAST STATEMENT HOLDS TRUE FOR SILICA ALSO.

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

BOILER PRESSURE PSIG	MAXIMUM TOTAL DISSOLVED SOLIDS (PPM TDS)	SUGGESTED TARGET (PPM TDS)
0 - 15	6000	5700
16 - 149	4000	3800
150 - 299	4000	3800
300 - 449	3500	3325
450 - 599	3000	2850
600 - 749	2500	2375
750	2000	1900

TARGET IS BASED ON 95% OF MAXIMUM WITH AN EXPECTED OPERATING RANGE OF 90-100% OF MAXIMUM.
NOTE - AFP 91-41 USES MAXIMUM TDS FOR CALCULATIONS

SELECTED OPERATING LEVEL FOR TOTAL DISSOLVED SOLIDS (PPM) IN BOILER = 1000.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

BOILER PRESSURE PSIG	MAXIMUM SILICA (PPM SIO2)	SUGGESTED TARGET (PPM SIO2)
0 - 15	200	190
16 - 149	200	190
150 - 300	150	142
300 - 450	90	85
450 - 599	40	38
600 - 749	30	28
750	20	19

TARGET IS BASED ON 95% OF MAXIMUM WITH AN EXPECTED
OPERATING RANGE WITHIN 90-100% OF MAXIMUM.
NOTE - AFP 91-41 USES MAXIMUM SIO2 IN ITS CALCULATIONS

SELECTED OPERATING LEVEL FOR SILICA (PPM SIO2) IN BOILER = 10.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

BOILER PRESSURE PSIG	RANGE PHOSPHATE (PPM PO4)	SUGGESTED TARGET (PPM PO4)
0 - 15	NOT USED	0
16 - 750	30 - 60	45

TARGET IS BASED ON CENTER OF RANGE. IF 0-15 PSIG BOILER HAS SOFTENED
MAKEUP THEN SUGGEST SAME TARGET AS 16-750 PSIG.

SELECTED OPERATING LEVEL FOR PHOSPHATE (PPM PO4) IN BOILER = ***0.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

CHEMICAL NAME (#)	FORMULA	PERCENT PO4	LB CHEM / 1K GAL FEEDWTR / PPM HD	LB NAOH / 100 LB PHOS CHEM
DISODIUM PHOSPHATE, DECAHYDRATE (1)	NA2HPO4*10H2O	26.0	0.02	11
DISODIUM PHOSPHATE, ANHYDROUS (2)	NA2HPO4	65.7	0.0082	28
TRISODIUM PHOSPHATE, DODECAHYDRATE (3)	NA3PO4*12H2O	25.1	0.021	0
TRISODIUM PHOSPHATE, MONOHYDRATE (4)	NA3PO4*H2O	52.0	0.01	0
SODIUM TRIPOLYPHOSPHATE, HEXAHYDRATE (5)	NA5P3O10*6H2O	61.1	0.0088	33.6
SODIUM TRIPOLYPHOSPHATE, ANHYDROUS (6)	NA5P3O10	76.4	0.0068	43.5
TETRASODIUM PYROPHOSPHATE (7)	NA4P2O7	71.0	0.0072	30.08
TETRASODIUM PYROPHOSPHATE, DECAHYDRATE (8)	NA4P2O7*10H2O	42.7	0.012	17.9
SODIUM HEXAMETAPHOSPHATE (9)	(NAPO3)6	90.5	0.0056	78.4

NUMBER (#) ABOVE OF CHEMICAL USED OR TYPE <0> FOR YOUR INPUT OR REVIEW 0

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

NAME OF PHOSPHATE CHEMICAL USED SODIUM*HEXAMETAPHOSPHATE**********

PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL USED = *90.5000
INSERT .0001 IF NO PHOSPHATE IS USED

POUNDS OF PHOSPHATE CHEMICAL REQUIRED TO TREAT 1000 GALLONS OF FEEDWATER PER PPM HARDNESS = ***.0056

POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF PHOSPHATE CHEMICAL = *78.4000

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

STEAM BOILER WATER TREATMENT PROGRAM

NOTE - THE PHOSPHATE DOSAGE APPLIES TO CALCIUM HARDNESS, NOT TOTAL HARDNESS, OF THE FEEDWATER. MAGNESIUM'S PREFERENTIAL REACTION IS WITH HYDROXIDE, THEN SILICA, AND FINALLY PHOSPHATE. MAGNESIUM SILICATE (SERPENTINE) IS MUCH MORE DESIRABLE THAN MAGNESIUM PHOSPHATE IN THE SAME WAY THAT CALCIUM PHOSPHATE (HYDROXYAPATITE) IS PREFERRED OVER CALCIUM SULFATE. IN EACH CASE, THE PREFERRED COMPOUND IS EASILY HANDLED WITH THE STANDARD SLUDGE CONDITIONER.

NOTE - AFP 91-41 ASSUMES 8.33 LBS/GALLON OF WATER TO DETERMINE THE GALLONS OF FEEDWATER AND CALCULATE THE PHOSPHATE NEEDED TO REACT WITH HARDNESS. PRESSURE AND TEMPERATURE AFFECT THIS VALUE AND THIS AFFECTS THE ACTUAL GALLONS THAT WILL BE MEASURED BY A WATER METER. THIS IS WHY CALCULATIONS ARE DONE IN POUNDS/HOUR AS IT IS NOT VOLUME DEPENDENT!

PRESS <ENTER> TO CONTINUE

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

* FEEDWATER (DEAERATING HEATER EFFLUENT) *

TEMPERATURE (DEG F)	PRESSURE (PSIG)	DENSITY (POUNDS/GALLON)
32	0 / 500	8.344 / 8.358
50	0 / 500	8.343 / 8.356
54.5	UNK	8.341
68	UNK	8.331
AFP 91-41		8.33
100	0 / 500	8.288 / 8.300
150	0 / 500	8.180 / 8.192
200	0 / 500	8.036 / 8.049
250	0 / 500	7.862 / 7.877

SELECTED FEEDWATER POUNDS/GALLON FOR CALCULATIONS = 7.1000

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

BOILER PRESSURE PSIG	RANGE OH ALKALINITY (PPM CACO3)	SUGGESTED OH TARGET (PPM CACO3)
0 - 15	300 - 550	360
16 - 149	220 - 500	265
150 - 299	220 - 500	265
300 - 449	180 - 450	215
450 - 599	170 - 425	205
600 - 749	170 - 550	205
750	170 - 425	205

TARGET IS BASED ON 120% OF MINIMUM.

SELECTED OPERATING LEVEL FOR HYDROXYL ALKALINITY (PPM CACO3)
IN BOILER = *170.00

PURITY (%) OF CAUSTIC SODA USED (DRY USUALLY 98) = 1.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

BOILER PRESSURE PSIG	CARBONATE ALKALINITY % BREAKDOWN
200	70 - 90
>150	80+
50 - 150	30 - 80
100	20 - 40
10 - 50	10 - 30

SELECTED % OF CARBONATE ALKALINITY BREAKDOWN IN BOILER = 1.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

BOILER PRESSURE PSIG	RANGE LIGNOSULFONATE (PPM TANNIC ACID)	SUGGESTED TARGET (PPM TANNIC ACID)
0 - 15	70 - 100	85
16 - 149	70 - 100	85
150 - 299	70 - 100	85
300 - 449	70 - 100	85
450 - 599	60 - 90	75
600 - 749	50 - 80	65
750	40 - 70	55

SELECTED LIGNOSULFONATE OPERATING LEVEL IN BOILER (PPM TANNIC ACID) = 40.00

PURITY (%) OF LIGNOSULFONATE CHEMICAL USED BASED ON TANNIC ACID CONTENT
(ASSUME 100 UNLESS MANUFACTURER OR ACTUAL TEST INDICATES OTHERWISE) = ***1.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

BOILER PRESSURE PSIG	RANGE SULFITE (PPM SO3)	SUGGESTED TARGET (PPM SO3)
0 - 15	30 - 60	45
16 - 149	30 - 60	45
150 - 299	30 - 60	45
300 - 449	20 - 40	30
450 - 599	20 - 40	30
600 - 749	15 - 30	23
750	NOT RECOMMENDED	

SELECTED SULFITE (PPM SO3) OPERATING LEVEL IN BOILER = .00

PURITY (%) OF SULFITE CHEMICAL USED (USUALLY 90) = ***1.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

NEUTRALIZING AMINE DOSAGES ARE DIFFICULT TO CALCULATE DUE TO MANY VARIABLES. FEEDWATER ALKALINITY IS IMPORTANT TO THE DETERMINATION OF AMINE DOSAGES.

AFP 91-41 SEEKS A 50/50 MIXTURE OF CYCLOHEXYLAMINE AND MORPHOLINE INITIALLY. GOAL IS TO ACHIEVE FINAL OPERATION AT PH 7.5 TO 8.0 THROUGHOUT THE CONDENSATE SYSTEM.

USE FREQUENT TESTS AND ADJUSTMENTS INITIALLY.
THEN TEST THE CONDENSATE SYSTEM THOROUGHLY TWICE YEARLY THEREAFTER.

PURITY (%) OF CYCLOHEXYLAMINE USED (60 OR 98) = 1.00
PURITY (%) OF MORPHOLINE USED (40, 91, OR 99) = 1.00

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

****

STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

DISTRIBUTION RATIO IS A MEASURE OF THE RELATIONSHIP BETWEEN THE AMINE IN VAPOR PHASE AND THE AMINE IN LIQUID PHASE. THE HIGHER THE RATIO THE MORE EASILY THE AMINE EVAPORATES AND STAYS IN VAPOR PHASE.

BOILER PRESSURE PSIG	DISTRIBUTION RATIO CYCLOHEXYLAMINE	MORPHOLINE
0	4.0	0.40
150	9.0	0.85
450	9.4	1.33
600	8.2	1.02

SELECTED DISTRIBUTION RATIO FOR CYCLOHEXYLAMINE = 4.00
SELECTED DISTRIBUTION RATIO FOR MORPHOLINE = 0.40

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

```
**                CHEMICAL DOSAGES                **
**          AVERAGE DOSAGES - POUNDS/DAY          **
**      FOR THE STEAM PRODUCTION OF INTEREST      **
**   TAKEN FROM THE BOILER WATER TREATMENT LOGS    **
```

INSERT DOSAGE OPPOSITE CHEMICAL NAME LISTED. IF SUBSTITUTE USED, INSERT NAME AND DOSAGE UNDERNEATH CHEMICAL WITH SAME FUNCTION.

```
CAUSTIC SODA (NAOH)                          **0.00
****************************************** **0.00
PHOSPHATE CHEMICAL LISTED IN AFP 91-41       **0.00
****************************************** **0.00
SODIUM SULFITE (NA2SO3)                      **0.00
****************************************** **0.00
LIGNOSULFONATE                               **0.00
****************************************** **0.00
CYCLOHEXYLAMINE                              **0.00
MORPHOLINE                                   **0.00
****************************************** **0.00
```

ABOVE DATA CORRECT (Y OR N) OR (E)XIT ?

Appendix Six

SAMPLE SCREENS TO
EDIT A FILE RECORD

Note - A single row of asterisks (*) or new pages separate the screens. The screens are in order of occurrence and reflect the actual operational data for Maxwell's Central Energy Plant's number 4 boiler.

```
**************************************************
**      STEAM BOILER WATER TREATMENT PROGRAM     **
**                                               **
**    WRITTEN BY MAJOR MICHAEL J.W. KAMINSKAS    **
**         AIR COMMAND AND STAFF COLLEGE         **
**             MAXWELL AFB AL 36112              **
**                 FEBRUARY 1988                 **
**  DIRECT COMMENTS TO HQ AFESC/DEMM AV 523-6351 **
**                  OR AFIT/DEE      AV 785-4552 **
**************************************************

 ENTER    FOR ACTION
 -----    ----------
   1      BOILER AND TREATMENT DATA FILE
   3      AFP 91-41 DOSAGE CALCULATIONS AND
            BASIC SYSTEM AND TREATMENT ANALYSIS
   5      ESTIMATED TREATMENT STABILITY POINT AND
            ADVANCED TREATMENT ANALYSIS
  16      EXIT FROM PROGRAM

    ACTION NUMBER *1
```

STEAM BOILER WATER TREATMENT PROGRAM

BOILER AND TREATMENT DATA FILE

ENTER	FOR ACTION
1	CREATE NEW DATA RECORD
3	UPDATE EXISTING DATA RECORD
5	DELETE EXISTING DATA RECORD
16	RETURN TO PREVIOUS MENU
21	CREATE NEW DATA FILE - RUN ONLY ONCE

ACTION NUMBER *3

****

STEAM BOILER WATER TREATMENT PROGRAM

INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAME (KEYFIELD) OF THE DATA RECORD YOU ARE INTERESTED IN. YOU WILL THEN HAVE TO STEP THROUGH THE RECORDS UNTIL YOU FIND THE ONE YOU WANT.

COMPUTER USER ID = I1K

PRESS <ENTER> TO CONTINUE

```
                    STEAM BOILER WATER TREATMENT PROGRAM

THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE DATA RECORD OBSERVED.

SELECT ACTION FOR RECORD OF INTEREST LISTED AT BOTTOM OF SCREEN.
    INPUT ACTION SELECTION S
 (S) = SELECT THIS RECORD TO REVIEW AND/OR EDIT
 (N) = GO TO NEXT RECORD
 (R) = RETAIN EXISTING RECORD NAME AFTER REVIEW/EDIT, THEN EXIT
 (C) = RENAME RECORD ABOVE AFTER EDIT AND CREATE NEW RECORD, THEN EXIT
 (E) = EXIT TO PREVIOUS MENU WITH NO ACTION TAKEN

    MODIFY ENTRIES BELOW ONLY AFTER EDIT FOR OPTION (C) ABOVE!
        COMPUTER USER ID      I1K
        TODAY'S DATE          880214
        BASE ID               MAX
        BUILDING NUMBER       1410***
        BOILER DESIGNATOR     4*
        RUN INDICATOR         A*
COMMENT DESCRIBING THIS DATA  ACTUAL*DATA*TO*DETERMINE*CURRENT*OPERATIONS**

    IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE USER ID REQUEST.

PRESS <ENTER> TO CONTINUE

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

SELECT INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

    ENTER FOR ACTION          ENTER FOR ACTION
    ----- ----------          ----- ----------
      1   ACCESS IDENTIFIED RECORD

    REVIEW SELECTION CRITERIA FOR THE FOLLOWING
      3   SYSTEM OPERATIONS     23  SILICA
      4   ALTITUDE OF BOILER    24  PHOSPHATE
      5   DEAERATOR OPERATION   25  HYDROXYL ALKALINITY
      6   PRETREATMENT          26  ALKALINITY BREAKDOWN
      7   MAKEUP QUALITY        27  LIGNOSULFONATE
      8   CONDENSATE QUALITY    28  SULFITE
      9   FEEDWATER QUALITY     29  NEUTRALIZING AMINE
     10   BOILER QUALITY        30  AMINE DISTRIBUTION
     11   STEAM QUALITY         31  RECORDED DOSAGES
     12   TOT DISSOLVED SOLIDS
       16      RETURN TO PREVIOUS MENU

        ACTION NUMBER *1
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

    INSTALLATION                              MAXWELL*AFB*AL******
    BUILDING NUMBER                           1410***
    BOILER DESIGNATION                        4*
    LAST NAME OF PERSON WHO MADE RECORD       KAMINSKAS******
COMMENT DESCRIBING THIS DATA    ACTUAL*DATA*TO*DETERMINE*CURRENT*OPERATIONS**

              **      STEAM PRODUCTION DATA      **

OPERATING GAUGE PRESSURE OF BOILER =  *150.00

RATED STEAM PRODUCTION (POUNDS/HOUR) OF BOILER          = **22000.00
ACTUAL STEAM PRODUCTION INVESTIGATED (POUNDS/HOUR QS)   = **14399.19

ESTIMATED LOSSES STEAM AND CONDENSATE (POUNDS/HOUR QL)  = ***2269.23

ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL (FT) = **168

**     NOTE - IF EXITING, ALL DATA ENTERED TO THAT POINT WILL BE SAVED!     **

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

              **      DEAERATING HEATER DATA      **

OPERATING TEMPERATURE OF DEAERATING HEATER (DEG F)  = *230.00
OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG)= ***5.00
OXYGEN (PPM 02) IN 'DEAERATING HEATER' EFFLUENT     =  ***.0400


          'Y' INDICATES APPLICABLE PRETREATMENT

    FILTER                          *
    SODIUM ZEOLITE SOFTENER         *
    HYDROGEN ZEOLITE SOFTENER       *
    SPLIT STREAM SOFTENING          *
    ZEOLITE DEALKALIZER             *
    COLD LIME-SODA SOFTENER         *
    HOT LIME-SODA SOFTENER          *
    DEGASIFIER                      *

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

 **      MAKEUP WATER QUALITY OF INTEREST      **
 **           AFTER ALL PRETREATMENT           **

   A * IN FRONT OF THE ITEM INDICATES IT AS A
     REGULAR TEST PERFORMED PER AFP 91-41

       TOTAL HARDNESS          (PPM CACO3)  **44.00
     * CALCIUM HARDNESS        (PPM CACO3)  **40.00
       MAGNESIUM HARDNESS      (PPM CACO3)  ***4.00
     * M ALKALINITY            (PPM CACO3)  *200.00
     * TOTAL DISSOLVED SOLIDS (PPM)        *221.00
       SILICA                  (PPM SIO2)   **28.00
       TOTAL SUSPENDED SOLIDS (PPM)        ***5.00

      ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

     **      CONDENSATE RETURN QUALITY OF INTEREST      **

   A * IN FRONT OF THE ITEM INDICATES IT AS A
      REGULAR TEST PERFORMED PER AFP 91-41
   THE NUMBER IN ( ) IS A GOOD THEORETICAL GUESS FOR
      PPM OF THAT ITEM IN GOOD QUALITY CONDENSATE.

       TOTAL HARDNESS          (0)(PPM CACO3)  ***0.00
     * CALCIUM HARDNESS        (0)(PPM CACO3)  ***0.00
       MAGNESIUM HARDNESS      (0)(PPM CACO3)  ***0.00
       M ALKALINITY           (15)(PPM CACO3)  **20.00
     * TOTAL DISSOLVED SOLIDS (15)(PPM)        ***8.00
       SILICA                  (0)(PPM SIO2)   ***0.00
       TOTAL SUSPENDED SOLIDS  (0)(PPM)        ***5.00
     * PH                    (7.5)             ***7.80
     * IRON                    (0)(PPM FE)     ****.02
     * COPPER                  (0)(PPM CU)     ***0.00

      ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

 **        FEEDWATER QUALITY OF INTEREST       **

   A * IN FRONT OF THE ITEM INDICATES IT IS
             NEEDED PER AFP 91-41

    * CALCIUM HARDNESS        (PPM CACO3)  **10.00
    * M ALKALINITY            (PPM CACO3)  **60.00
    * P ALKALINITY            (PPM CACO3)  ***0.00
    * TOTAL DISSOLVED SOLIDS  (PPM)        *119.00
    * SILICA                  (PPM SIO2)   ***6.00

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

INSERT INFO IN SPACES SHOWN, PRESS <ENTER> WHEN DONE

 **          BOILER QUALITY OF INTEREST        **

   A * IN FRONT OF THE ITEM INDICATES IT IS
               NEEDED PER AFP 91-41

VALUES TAKEN FROM WATER TREATMENT LOG (AF FORM 1459)

    * HYDROXYL ALKALINITY     (PPM CACO3)  *286.20
    * TOTAL DISSOLVED SOLIDS  (PPM)        1524.70
    NOTE - TDS SAMPLES TAKEN FROM CONTINUOUS BLOWDOWN WHEN POSSIBLE.
           TSS SAMPLES SHOULD BE TAKEN FROM THE BOTTOM BLOWDOWN.
    * PHOSPHATE               (PPM PO4)    **48.30
    * SULFITE                 (PPM SO3)    **49.50
    * LIGNOSULFONATE    (PPM TANNIC ACID)  ***0.00
    * PH                      (PPM)        **11.29

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

        **  STEAM QUALITY OF INTEREST  **

TOTAL DISSOLVED SOLIDS IN STEAM (ASSUME 0 IF PURE) = ***0.00
               SILICA IN STEAM (ASSUME 0 IF PURE) = ***0.00

          **   CHEMICAL LEVELS MAINTAINED    **

SELECTED OPERATING LEVEL FOR TOTAL DISSOLVED SOLIDS (PPM)   = 1524.71
SELECTED OPERATING LEVEL FOR SILICA            (PPM SIO2)   = *142.00
SELECTED OPERATING LEVEL FOR PHOSPHATE          (PPM PO4)   = **48.30
  NAME OF PHOSPHATE CHEMICAL USED     SODIUM*HEXAMETAPHOSPHATE**********
  PERCENTAGE (%) (USE MINIMUM 0.0001) OF PO4 IN CHEMICAL USED  = *90.5000
  POUNDS OF PHOSPHATE CHEMICAL REQUIRED TO TREAT 1000 GALLONS OF FEEDWATER PER
    PPM HARDNESS  = ***.0056
  POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF SODIUM
    HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF PHOSPHATE CHEMICAL  = *78.4000

SELECTED FEEDWATER POUNDS/GALLON FOR CALCULATIONS   = **7.9316

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

          ** CHEMICAL LEVELS MAINTAINED (CONT) **

SELECTED OPERATING LEVEL FOR HYDROXYL ALKALINITY (PPM CACO3)  = *286.20
 PURITY (%) OF CAUSTIC SODA USED (DRY USUALLY 98)  = **98.00

SELECTED % OF CARBONATE ALKALINITY BREAKDOWN IN BOILER  = **80.00

SELECTED LIGNOSULFONATE OPERATING LEVEL (PPM TANNIC ACID)  = **85.00
 PURITY (%) OF LIGNOSULFONATE CHEMICAL USED BASED ON TANNIC ACID CONTENT
 (ASSUME 100 UNLESS MANUFACTURER OR ACTUAL TEST INDICATES OTHERWISE)  = *100.00

SELECTED SULFITE (PPM SO3) OPERATING LEVEL   = **49.50
 PURITY (%) OF SULFITE CHEMICAL USED (USUALLY 90)  = **90.00

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?
```

```
                    STEAM BOILER WATER TREATMENT PROGRAM

MODIFY INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

          ** CHEMICAL LEVELS MAINTAINED (CONT) **

  PURITY (%) OF CYCLOHEXYLAMINE USED (60 OR 98) = **60.00
  PURITY (%) OF MORPHOLINE USED (40, 91, OR 99) = **40.00

SELECTED DISTRIBUTION RATIO FOR CYCLOHEXYLAMINE  = ***9.00
SELECTED DISTRIBUTION RATIO FOR MORPHOLINE       = ****.85

     ABOVE DATA CORRECT ( Y OR N ) OR (E)XIT  ?

*******************************************************************************

                    STEAM BOILER WATER TREATMENT PROGRAM

SELECT INFO AS NECESSARY, PRESS <ENTER> WHEN DONE

    ENTER FOR ACTION          ENTER FOR ACTION
    ----- ----------          ----- ----------
      1   ACCESS IDENTIFIED RECORD

    REVIEW SELECTION CRITERIA FOR THE FOLLOWING
      3   SYSTEM OPERATIONS     23  SILICA
      4   ALTITUDE OF BOILER    24  PHOSPHATE
      5   DEAERATOR OPERATION   25  HYDROXYL ALKALINITY
      6   PRETREATMENT          26  ALKALINITY BREAKDOWN
      7   MAKEUP QUALITY        27  LIGNOSULFONATE
      8   CONDENSATE QUALITY    28  SULFITE
      9   FEEDWATER QUALITY     29  NEUTRALIZING AMINE
     10   BOILER QUALITY        30  AMINE DISTRIBUTION
     11   STEAM QUALITY         31  RECORDED DOSAGES
     12   TOT DISSOLVED SOLIDS
       16      RETURN TO PREVIOUS MENU

        ACTION NUMBER 16
```

STEAM BOILER WATER TREATMENT PROGRAM

THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE DATA RECORD OBSERVED.

SELECT ACTION FOR RECORD OF INTEREST LISTED AT BOTTOM OF SCREEN.
INPUT ACTION SELECTION R
(S) = SELECT THIS RECORD TO REVIEW AND/OR EDIT
(N) = GO TO NEXT RECORD
(R) = RETAIN EXISTING RECORD NAME AFTER REVIEW/EDIT, THEN EXIT
(C) = RENAME RECORD ABOVE AFTER EDIT AND CREATE NEW RECORD, THEN EXIT
(E) = EXIT TO PREVIOUS MENU WITH NO ACTION TAKEN

MODIFY ENTRIES BELOW ONLY AFTER EDIT FOR OPTION (C) ABOVE!

COMPUTER USER ID	I1K
TODAY'S DATE	880214
BASE ID	MAX
BUILDING NUMBER	1410***
BOILER DESIGNATOR	4*
RUN INDICATOR	A*
COMMENT DESCRIBING THIS DATA	ACTUAL*DATA*TO*DETERMINE*CURRENT*OPERATIONS**

IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE USER ID REQUEST.

PRESS <ENTER> TO CONTINUE

Appendix Seven

SAMPLE SCREENS TO
DELETE A FILE RECORD

Note - A single row of asterisks (*) or new pages separate the screens. The screens are in order of occurrence.

```
**************************************************
**      STEAM BOILER WATER TREATMENT PROGRAM     **
**                                               **
**    WRITTEN BY MAJOR MICHAEL J.W. KAMINSKAS    **
**         AIR COMMAND AND STAFF COLLEGE         **
**             MAXWELL AFB AL 36112              **
**                 FEBRUARY 1988                 **
**  DIRECT COMMENTS TO HQ AFESC/DEMM AV 523-6351 **
**                  OR AFIT/DEE      AV 785-4552 **
**************************************************

 ENTER    FOR ACTION
 -----    ----------
   1      BOILER AND TREATMENT DATA FILE
   3      AFP 91-41 DOSAGE CALCULATIONS AND
            BASIC SYSTEM AND TREATMENT ANALYSIS
   5      ESTIMATED TREATMENT STABILITY POINT AND
            ADVANCED TREATMENT ANALYSIS
  16      EXIT FROM PROGRAM

    ACTION NUMBER *1
```

STEAM BOILER WATER TREATMENT PROGRAM

BOILER AND TREATMENT DATA FILE

ENTER	FOR ACTION
1	CREATE NEW DATA RECORD
3	UPDATE EXISTING DATA RECORD
5	DELETE EXISTING DATA RECORD
16	RETURN TO PREVIOUS MENU
21	CREATE NEW DATA FILE - RUN ONLY ONCE

ACTION NUMBER *5

****

STEAM BOILER WATER TREATMENT PROGRAM

INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAME (KEYFIELD) OF THE DATA RECORD YOU ARE INTERESTED IN. YOU WILL THEN HAVE TO STEP THROUGH THE RECORDS UNTIL YOU FIND THE ONE YOU WANT.

COMPUTER USER ID = I1K

PRESS <ENTER> TO CONTINUE

STEAM BOILER WATER TREATMENT PROGRAM

THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE DATA RECORD OBSERVED.

SELECT ACTION FOR RECORD OF INTEREST LISTED BELOW:
INPUT ACTION SELECTION D
(D) = DELETE THIS RECORD
(N) = GO TO NEXT RECORD
(E) = NO ACTION, EXIT TO PREVIOUS MENU

RECORD OF INTEREST	
COMPUTER USER ID	I1K
TODAY'S DATE	880109
BASE ID	MAX
BUILDING NUMBER	1401
BOILER DESIGNATOR	A
RUN INDICATOR	TT
COMMENT DESCRIBING THIS DATA	TEST PROGRAM

IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE USER ID REQUEST.

PRESS <ENTER> TO CONTINUE
DO YOU WANT TO DELETE ANOTHER RECORD (Y OR N) ?

Appendix Eight

SAMPLE SCREENS FOR BASIC CALCULATIONS PER
AFP 91-41 AND SYSTEM OPERATION ANALYSIS

Note - A single row of asterisks (*) or new pages separate the screens. The screens are in order of occurrence.

```
**********************************************************
**       STEAM BOILER WATER TREATMENT PROGRAM           **
**                                                      **
**     WRITTEN BY MAJOR MICHAEL J.W. KAMINSKAS          **
**          AIR COMMAND AND STAFF COLLEGE               **
**              MAXWELL AFB AL 36112                    **
**                  FEBRUARY 1988                       **
**  DIRECT COMMENTS TO HQ AFESC/DEMM AV 523-6351        **
**                   OR AFIT/DEE      AV 785-4552       **
**********************************************************

 ENTER     FOR ACTION
 -----     ----------
   1       BOILER AND TREATMENT DATA FILE
   3       AFP 91-41 DOSAGE CALCULATIONS AND
             BASIC SYSTEM AND TREATMENT ANALYSIS
   5       ESTIMATED TREATMENT STABILITY POINT AND
             ADVANCED TREATMENT ANALYSIS
  16       EXIT FROM PROGRAM

    ACTION NUMBER *3
```

STEAM BOILER WATER TREATMENT PROGRAM

INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAME (KEYFIELD) OF THE DATA RECORD YOU ARE INTERESTED IN. YOU WILL THEN HAVE TO STEP THROUGH THE RECORDS UNTIL YOU FIND THE ONE YOU WANT.

COMPUTER USER ID = I1K

NOTE - THE CALCULATIONS ARE BASED ON INITIAL MAKEUP AND CONDENSATE QUALITIES, AS WELL AS SYSTEM OPERATION. ADJUST RECORD VALUES TO ADJUST THE INPUT VALUES, TO THE CALCULATIONS.
A DECISION FOR ONE PRINTOUT IS AVAILABLE AT THE END OF THE RUN.

PRESS <ENTER> TO CONTINUE

****

STEAM BOILER WATER TREATMENT PROGRAM

THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE DATA RECORD OBSERVED.

SELECT ACTION FOR RECORD OF INTEREST LISTED BELOW:
INPUT ACTION SELECTION S
(S) = SELECT THIS RECORD
(N) = GO TO NEXT RECORD
(E) = NO ACTION, EXIT TO PREVIOUS MENU

RECORD OF INTEREST

COMPUTER USER ID	I1K
TODAY'S DATE	880214
BASE ID	MAX
BUILDING NUMBER	1410
BOILER DESIGNATOR	4
RUN INDICATOR	P
COMMENT DESCRIBING THIS DATA	ACTUAL DATA TEMPERED BY AFP 91-41 APPROACH

IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE USER ID REQUEST.

PRESS <ENTER> TO CONTINUE

DO YOU WANT A PRINTOUT OF THIS RUN ? Y

(Y) IF YOU WANT A PRINTOUT
(N) IF YOU WANT TO RETURN TO PREVIOUS MENU

PRESS <ENTER> TO CONTINUE

NOTE - TWO BELLS INDICATE PRINT FILE ACCESSED
SCREEN THEN RETURNS TO PREVIOUS MENU

Appendix Nine

SAMPLE SCREENS FOR ADVANCED CALCULATIONS
AND TREATMENT ANALYSIS

Note - A single row of asterisks (*) or new pages separate the screens. The screens are in order of occurrence.

```
**********************************************************
**       STEAM BOILER WATER TREATMENT PROGRAM           **
**                                                      **
**     WRITTEN BY MAJOR MICHAEL J.W. KAMINSKAS          **
**          AIR COMMAND AND STAFF COLLEGE               **
**              MAXWELL AFB AL 36112                    **
**                  FEBRUARY 1988                       **
**  DIRECT COMMENTS TO HQ AFESC/DEMM AV 523-6351        **
**                     OR AFIT/DEE      AV 785-4552     **
**********************************************************

 ENTER     FOR ACTION
 -----     ----------
   1       BOILER AND TREATMENT DATA FILE
   3       AFP 91-41 DOSAGE CALCULATIONS AND
             BASIC SYSTEM AND TREATMENT ANALYSIS
   5       ESTIMATED TREATMENT STABILITY POINT AND
             ADVANCED TREATMENT ANALYSIS
  16       EXIT FROM PROGRAM

    ACTION NUMBER *5
```

STEAM BOILER WATER TREATMENT PROGRAM

INPUT THE COMPUTER USER ID (EG. I1K) FOR THE RECORD NAME (KEYFIELD) OF THE DATA RECORD YOU ARE INTERESTED IN. YOU WILL THEN HAVE TO STEP THROUGH THE RECORDS UNTIL YOU FIND THE ONE YOU WANT.

COMPUTER USER ID = I1K

NOTE - THE CALCULATIONS ARE BASED ON INITIAL MAKEUP AND CONDENSATE QUALITIES, AS WELL AS SYSTEM OPERATION. ADJUST RECORD VALUES TO ADJUST THE INPUT VALUES TO THE CALCULATIONS.

A DECISION FOR ONE PRINTOUT IS AVAILABLE AT THE END OF THE RUN.

PRESS <ENTER> TO CONTINUE

****

STEAM BOILER WATER TREATMENT PROGRAM

THIS SCREEN CONTAINS THE RECORD NAME (KEYFIELD) OF THE DATA RECORD OBSERVED.

SELECT ACTION FOR RECORD OF INTEREST LISTED BELOW!
INPUT ACTION SELECTION S
(S) = SELECT THIS RECORD
(N) = GO TO NEXT RECORD
(E) = NO ACTION, EXIT TO PREVIOUS MENU

RECORD OF INTEREST

COMPUTER USER ID	I1K
TODAY'S DATE	880214
BASE ID	MAX
BUILDING NUMBER	1410
BOILER DESIGNATOR	4
RUN INDICATOR	A
COMMENT DESCRIBING THIS DATA	ACTUAL DATA TO DETERMINE CURRENT OPERATIONS

IF END OF FILE IS REACHED, PROGRAM WILL GO BACK TO THE USER ID REQUEST.

PRESS <ENTER> TO CONTINUE

STEAM BOILER WATER TREATMENT PROGRAM

THE ONLY CALCULATED QUANTITY THAT CAN BE CONSTRAINED IS MAKEUP FLOW. THIS IS ADVANTAGEOUS WHEN COMPARING RESULTS TO AN ACTUAL OPERATING SYSTEM. MAKEUP IS USUALLY THE MOST ACCURATE METERED QUANTITY AVAILABLE.

DO YOU WISH TO CONSTRAIN MAKEUP FLOW (Y OR N) ? N

IF MAKEUP IS CONSTRAINED, WHAT QUANTITY IN POUNDS/HOUR DO YOU WANT TO INVESTIGATE? ******0.00

PRESS <ENTER> TO CONTINUE

****

DO YOU WANT A PRINTOUT OF THIS RUN ? Y

(Y) IF YOU WANT A PRINTOUT
(N) IF YOU WANT TO RETURN TO PREVIOUS MENU

PRESS <ENTER> TO CONTINUE

NOTE - TWO BELLS INDICATE PRINT FILE ACCESSED
SCREEN THEN RETURNS TO PREVIOUS MENU

Appendix Ten

HARDCOPY OUTPUT OF BASIC CALCULATIONS PER
AFP 91-41 WITH SYSTEM OPERATION ANALYSIS

ACSC/AFESC/AFIT
PROGRAM FOR STEAM BOILER WATER TREATMENT
COMPUTATION OF DAILY CHEMICAL DOSAGES
AND BASIC ANALYSIS IAW AFP 91-41

DAILY DOSAGES CALCULATED ARE INITIAL VALUES ONLY. TEST RESIDUALS AND ADJUST DOSAGES AS SYSTEM STABILIZES TO ITS FINAL OPERATING POINT.

INSTALLATION WHERE BOILER IS LOCATED	MAXWELL AFB AL
BUILDING NUMBER WHERE BOILER LOCATED	1410
BOILER DESIGNATION	4
NAME OF PERSON MAKING THIS RUN	KAMINSKAS
COMMENT DESCRIBING THIS DATA	ACTUAL DATA TEMPERED BY AFP 91-41 APPROACH

** PRETREATMENT (EXISTING OR ANALYZED) IS AS FOLLOWS: **

NO PRETREATMENT SPECIFIED

***** MAKEUP WATER QUALITY OF INTEREST *****
***** AFTER ALL PRETREATMENT *****

TOTAL HARDNESS	(PPM CACO3)	11.00
CALCIUM HARDNESS	(PPM CACO3)	10.00
MAGNESIUM HARDNESS	(PPM CACO3)	1.00
M ALKALINITY	(PPM CACO3)	60.00
TOTAL DISSOLVED SOLIDS	(PPM)	119.00
SILICA	(PPM SIO2)	7.77
TOTAL SUSPENDED SOLIDS	(PPM)	0.00

***** CONDENSATE RETURN QUALITY OF INTEREST *****

TOTAL HARDNESS	(PPM CACO3)	11.00
CALCIUM HARDNESS	(PPM CACO3)	10.00
MAGNESIUM HARDNESS	(PPM CACO3)	1.00
M ALKALINITY	(PPM CACO3)	60.00
TOTAL DISSOLVED SOLIDS	(PPM)	119.00

SILICA	(PPM SIO2)	7.77
TOTAL SUSPENDED SOLIDS	(PPM)	0.00
PH		7.50
IRON	(PPM FE)	0.00
COPPER	(PPM CU)	0.00

INVESTIGATE AND CORRECT DETRIMENTAL INLEAKAGE INTO CONDENSATE SYSTEM!

***** DEAERATING HEATER DATA *****

OPERATING TEMPERATURE OF DEAERATING HEATER	(DEG F) =	230.00
OPERATING GAUGE PRESSURE OF DEAERATING HEATER	(PSIG) =	5.00
ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL	(FT) =	0.00
EFFLUENT OF YOUR 'DEAERATING HEATER'	(PPM O2) =	0.0070

***** STEAM PRODUCTION DATA *****

OPERATING GAUGE PRESSURE OF BOILER (PSIG)	=	150.00
RATED STEAM PRODUCTION OF BOILER (POUNDS/HOUR)	=	22,000.00
MAXIMUM EVAPORATION (POUNDS/HOUR QSM)	=	21,379.31
EVAPORATION CAPACITY INVESTIGATED (QS)	=	14,400.00

***** DETERMINE OPERATING CONDITIONS *****

ESTIMATED STEAM AND CONDENSATE LOSSES (POUNDS/HOUR QL)	=	0.00

NOTE THAT A STRICT AFP 91-41 CALCULATION WOULD SET QL = 0

CONDENSATE RETURNED (POUNDS/HOUR QCR)	=	14,400.00
TOTAL DISSOLVED SOLIDS IN STEAM (PPM)	=	0.00
MAKEUP (POUNDS/HOUR QMU) BASED ON TDS	=	441.53
SILICA IN STEAM	=	0.00
MAKEUP (POUNDS/HOUR QMU) BASED ON SIO2	=	786.66
MAKEUP LIMITED BY SIO2 (POUNDS/HOUR QMU)	=	786.66

***** FEEDWATER QUALITY *****

FEEDWATER (POUNDS/HOUR QF)	=	15,186.66
TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) BY CALCULATION	=	119.00
TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) BY TEST	=	119.00

COMPARE CALCULATED TO ACTUAL TESTED VALUES.

SILICA IN FEEDWATER BY CALCULATION	(PPM SIO2)	=	7.76
SILICA IN FEEDWATER BY TEST	(PPM SIO2)	=	7.77

COMPARE CALCULATED TO ACTUAL TESTED VALUES.

***** CYCLES OF CONCENTRATION *****

OPERATIONAL LIMIT SET FOR TDS (PPM)	=	4,000.00
OPERATIONAL LIMIT SET FOR SILICA (PPM SIO2)	=	150.00
CYCLES BASED ON TDS - DESIGN LIMIT	=	33.61
CYCLES BASED ON SILICA - DESIGN LIMIT	=	19.30
OPERATING CYCLES OF CONCENTRATION	=	19.30
CALCULATED OPERATING BOILER TDS (PPM)	=	2,297.29

COMPARE CALCULATED TO ACTUAL TESTED VALUES.

CALCULATED OPERATING BOILER SILICA (PPM SIO2)	=	150.00

COMPARE CALCULATED TO ACTUAL TESTED VALUES.

***** DETERMINE BLOWDOWN *****

BLOWDOWN (POUNDS/HOUR QBD)	=	786.66

COMPARE CALCULATED TO ACTUAL METERED OR LOG ENTRY VALUES.

***** DETERMINE PHOSPHATE DOSAGE PER DAY *****

PHOSPHATE CHEMICAL USED SODIUM HEXAMETAPHOSPHATE
PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL = 90.50
POUNDS OF PHOSPHATE CHEMICAL REQUIRED TO TREAT 1,000 GALLONS OF FEEDWATER PER PPM HARDNESS = 0.0056
POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF PHOSPHATE CHEMICAL = 78.4000

RESIDUAL PO4 DESIRED IN BOILER (PPM PO4)	=	60.00
POUNDS OF PHOSPHATE CHEMICAL/DAY FOR RESIDUAL	=	1.25
POUNDS OF PHOSPHATE CHEMICAL/DAY FOR HARDNESS	=	2.69
TOTAL POUNDS OF PHOSPHATE CHEMICAL/DAY AFP 91-41	=	3.95

***** DETERMINE CAUSTIC SODA DOSAGE PER DAY *****

PURITY (%) OF CAUSTIC SODA USED	=	98.00
POUNDS/DAY FOR PHOSPHATE HYDROLYSIS AFP 91-41	=	3.16
CALCULATED SILICA IN FEEDWATER	=	7.76
SILICA IN FEEDWATER BY TEST	=	7.77

COMPARE CALCULATED TO ACTUAL TESTED VALUES.

SILICA NEEDED FOR MAGNESIUM REACTIONS	=	1.94

SUFFICIENT SILICA FOR MAGNESIUM REACTION TO FORM SERPENTINE.

SILICA/PHOSPHATE RATIO FAVORABLE TO FORM SERPENTINE - AFP 91-41.

TOTAL CAUSTIC SODA POUNDS/DAY	=	3.16

***** DETERMINE LIGNOSULFONATE DOSAGE PER DAY *****

RESIDUAL PPM LIGNOSULFONATE DESIRED = 70.00
PURITY (%) OF LIGNOSULFONATE CHEMICAL = 100.00
LIGNOSULFONATE DOSAGE FOR RESIDUAL = 1.32
LIGNOSULFONATE DOSAGE FOR FDWTR 20 % M ALKALINITY = 0.22
LIGNOSULFONATE DOSAGE REQUIRED (POUNDS/DAY) = 1.32

***** DETERMINE SULFITE DOSAGE PER DAY *****

THE DEAERATING HEATER IS NOT BOILING PROPERLY! CHECK CALIBRATION OF THE GAUGES AND TEST THE OXYGEN CONTENT OF THE FEEDWATER.
DESIGN LIMIT PPM O2 FROM DEAERATOR NOT ACHIEVED = 0.0070

RESIDUAL SULFITE (PPM SO3) DESIRED = 45.00
PURITY (%) OF SULFITE CHEMICAL = 90.00
SODIUM SULFITE NEEDED FOR RESIDUAL = 1.49
SODIUM SULFITE REQUIRED (POUNDS/DAY) = 1.49

***** DETERMINE NEUTRALIZING AMINE DOSAGE *****
***** FOR A 50/50 MIXTURE OF *****
***** CYCLOHEXYLAMINE AND MORPHOLINE *****

P ALKALINITY IN FEEDWATER BY TEST = 0.00
CALCULATED M ALKALINITY IN FEEDWATER = 60.00
M ALKALINITY IN FEEDWATER BY TEST = 60.00
COMPARE CALCULATED TO ACTUAL TESTED VALUES.

PER CENT OF CARBONATE ALKALINITY BREAKDOWN = 80.00
CALCULATED FEEDWATER BICARBONATE ALKALINITY = 60.00
CALCULATED FEEDWATER CARBONATE ALKALINITY = 0.00
EQUIV CARBON DIOXIDE (PPM CO2) IN FEEDWATER = 47.51

PURITY (%) OF CYCLOHEXYLAMINE USED = 60.00
PURITY (%) OF MORPHOLINE USED = 40.00
CYCLOHEXYLAMINE DOSAGE (LB/DAY) (50/50 MIX) = 32.41
MORPHOLINE DOSAGE (LB/DAY) (50/50 MIX) = 42.97
FINAL STEADY STATE DOSE IS ABOUT 20 % OF THIS INITIAL DOSE.
COMPARE CALCULATED TO ACTUAL DOSAGES.

NOTE THE MIXTURE RATIOS AND MAXIMUM DOSAGES ALLOWED FOR NEUTRALIZING AMINES PER AFP 91-41.

DO NOT USE AMINES IF STEAM COMES INTO DIRECT CONTACT WITH FOOD. IMMEDIATELY HAVE SERVICES PROGRAM EQUIPMENT REPLACEMENT AS THIS IS AGAINST STATED POLICY.

THESE CHEMICAL DOSAGES WILL NOW AFFECT THE TOTAL DISSOLVED SOLIDS AND OTHER CONSTITUENT LEVELS IN THE BOILER AND THUS AFFECT THE CYCLES OF CONCENTRATION.

RUN THE ADVANCED ANALYSIS CALCULATIONS TO RECEIVE A BETTER ESTIMATE OF THE DAILY DOSAGES AT THE FINAL SYSTEM EQUILIBRIUM POINT FOR COMPARISON WITH THE ACTUAL DOSAGES PROVIDED TO THE BOILER.

Appendix Eleven

HARDCOPY OUTPUT OF ADVANCED CALCULATIONS
AND TREATMENT ANALYSIS

ACSC/AFESC/AFIT
PROGRAM FOR STEAM BOILER WATER TREATMENT
COMPUTATION OF DAILY CHEMICAL DOSAGES
ADVANCED TREATMENT ANALYSIS

DOSAGES ARE CALCULATED ESTIMATES OF FINAL DOSAGES AT THE SYSTEM OPERATING POINT. COMPARISON WITH ACTUAL DOSAGES WILL REVEAL SYSTEM OPERATING EFFICIENCY AND TESTING ACCURACY. ADJUSTING DATA RECORDS ALLOWS COMPARATIVE ANALYSIS FOR PROPOSED SYSTEM IMPROVEMENTS OR REPAIR PROJECTS.

INSTALLATION WHERE BOILER IS LOCATED	MAXWELL AFB AL
BUILDING NUMBER WHERE BOILER LOCATED	1410
BOILER DESIGNATION	4
NAME OF PERSON MAKING THIS RUN	KAMINSKAS
COMMENT DESCRIBING THIS DATA	ACTUAL DATA TO DETERMINE CURRENT OPERATIONS

***** MAKEUP WATER QUALITY OF INTEREST *****
***** AFTER ALL PRETREATMENT *****

CALCIUM HARDNESS	(PPM CACO3)	40.00
MAGNESIUM HARDNESS	(PPM CACO3)	4.00
M ALKALINITY	(PPM CACO3)	200.00
TOTAL DISSOLVED SOLIDS	(PPM)	221.00
SILICA	(PPM SIO2)	28.00
TOTAL SUSPENDED SOLIDS	(PPM)	5.00

***** CONDENSATE RETURN QUALITY OF INTEREST *****

CALCIUM HARDNESS	(PPM CACO3)	0.00
MAGNESIUM HARDNESS	(PPM CACO3)	0.00
M ALKALINITY	(PPM CACO3)	20.00
TOTAL DISSOLVED SOLIDS	(PPM)	8.00
SILICA	(PPM SIO2)	0.00
TOTAL SUSPENDED SOLIDS	(PPM)	5.00

***** DEAERATING HEATER DATA *****

OPERATING TEMPERATURE OF DEAERATING HEATER (DEG F) = 230.00

OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG) = 5.00
ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL (FT) = 168.00
EFFLUENT OF YOUR 'DEAERATING HEATER' (PPM O2) = 0.0400

***** STEAM PRODUCTION DATA *****

OPERATING GAUGE PRESSURE OF BOILER (PSIG) = 150.00
RATED STEAM PRODUCTION OF BOILER (POUNDS/HOUR) = 22,000.00
MAXIMUM EVAPORATION (POUNDS/HOUR QSM) = 21,379.43
EVAPORATION CAPACITY INVESTIGATED (QS) = 14,399.19

***** DETERMINE OPERATING CONDITIONS *****

ESTIMATED STEAM AND CONDENSATE LOSSES (POUNDS/HOUR QL) = 2,269.23
CONDENSATE RETURNED (POUNDS/HOUR QCR) = 12,129.96

TOTAL DISSOLVED SOLIDS IN STEAM (PPM) = 0.00

SILICA IN STEAM = 0.00

MAKEUP (POUNDS/HOUR QMU) BASED ON TDS = 2,786.81
MAKEUP (POUNDS/HOUR QMU) BASED ON SIO2 = 2,787.87
MAKEUP (POUNDS/HOUR QMU) BASED ON TSS = 4,383.03

MAKEUP LIMITED BY SIO2 (POUNDS/HOUR QMU) = 2,787.87
WARNING-CALCULATIONS PREDICT EXCESSIVE SUSPENDED SOLIDS IN BOILER.
INVESTIGATE HARD MAKEUP WITH NO PHOSPHATE, SOFTENING AND PHOSPHATE, AND
ELIMINATION OF CONDENSATE RETURN HARDNESS CONTAMINATION!

COMPARE THIS CALCULATED MAKEUP FLOW TO THE METERED VALUE.

***** FEEDWATER QUALITY *****

FEEDWATER (POUNDS/HOUR QF) = 14,917.83

TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) = 51.20
BY CALCULATION
TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) = 119.00
BY TEST

SILICA IN FEEDWATER (PPM SIO2) = 5.23
BY CALCULATION
SILICA IN FEEDWATER (PPM SIO2) = 6.00
BY TEST

TOTAL SUSPENDED SOLIDS IN FEEDWATER (PPM) = 4.99
BY CALCULATION

***** CYCLES OF CONCENTRATION *****

LIMIT SELECTED FOR TOTAL DISSOLVED SOLIDS (PPM) = 1,524.71

LIMIT SELECTED FOR SILICA (PPM SIO2)	=	142.00
LIMIT SELECTED FOR TOTAL SUSPENDED SOLIDS (PPM)	=	121.97
CYCLES BASED ON TDS - DESIGN LIMIT	=	27.07
CYCLES BASED ON SILICA - DESIGN LIMIT	=	28.76
CYCLES BASED ON TSS - DESIGN LIMIT	=	9.25
ACTUAL CYCLES BASED ON TDS	=	31.63
ACTUAL CYCLES BASED ON SILICA	=	27.13
ACTUAL CYCLES BASED ON TSS	=	75.79
OPERATING CYCLES OF CONCENTRATION	=	28.76
CALCULATED OPERATING BOILER TDS (PPM)	=	1,619.91
CALCULATED OPERATING BOILER SILICA (PPM SIO2)	=	142.00
CALCULATED OPERATING BOILER TSS (PPM)	=	378.97

***** DETERMINE BLOWDOWN *****

BLOWDOWN (POUNDS/HOUR QBD)	=	518.64

***** DETERMINE PHOSPHATE DOSAGE PER DAY *****

CALCULATED FEEDWATER CALCIUM HARDNESS (PPM CACO3)	=	7.47
FEEDWATER CALCIUM HARDNESS (PPM CACO3) BY TEST	=	10.00
PHOSPHATE CHEMICAL USED		*SODIUM* HEXAMETAPHOSPHATE
PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL	=	90.50

POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF PHOSPHATE CHEMICAL = 78.4000

RESIDUAL PO4 DESIRED IN BOILER (PPM PO4)	=	48.30
POUNDS OF PHOSPHATE CHEMICAL/DAY FOR RESIDUAL	=	0.66
POUNDS OF PHOSPHATE CHEMICAL/DAY FOR CA HARDNESS	=	1.68
TOTAL POUNDS-PHOSPHATE CHEMICAL/DAY-ADVANCED CALC	=	2.35
ACTUAL DOSAGE OF PHOSPHATE CHEMICAL (LB/DAY)	=	3.54

***** DETERMINE CAUSTIC SODA DOSAGE PER DAY *****

PURITY (%) OF CAUSTIC SODA USED	=	98.00
NAOH POUNDS/DAY FOR PO4 HYDROLYSIS-ADVANCED CALC	=	1.88
NAOH POUNDS/DAY FOR CALCIUM HYDROXYAPATITE	=	0.21
CALCULATED MAGNESIUM HARDNESS IN FEEDWATER	=	0.74
CALCULATED SILICA IN FEEDWATER	=	5.23
SILICA IN FEEDWATER BY TEST	=	6.00
SILICA NEEDED FOR MAGNESIUM REACTIONS	=	1.13
NAOH POUNDS/DAY FOR MAGNESIUM HYDROXIDE	=	0.00
NAOH POUNDS/DAY FOR SERPENTINE (MG+SILICA)	=	0.07
TOTAL NAOH POUNDS/DAY FOR MAGNESIUM REACTIONS	=	0.07

SUFFICIENT SILICA FOR MAGNESIUM REACTION TO FORM SERPENTINE.

HYDROXYL RESIDUAL DESIRED (PPM CACO3) = 286.20
HYDROXYL RESIDUAL BY TEST = 286.20
BREAKDOWN OF NATURALLY OCCURRING ALKALINITY GIVES
TOTAL ESTIMATED HYDROXYL ALKALINITY IN BOILER = 1,234.25
ESTIMATED HYDROXYL ALKALINITY IN BOILER IS HEAVILY DEPENDENT ON PERCENT CARBONATE ALKALINITY SELECTED, USE OF NEUTRALIZING AMINES, AND REACTIONS NOT TAKEN INTO ACCOUNT. ACTUAL VALUES MEASURED MAY BE AS LITTLE AS 20 PERCENT OF THE ABOVE ESTIMATE.
THERE IS NO HYDROXYL DEFICIENCY IN ATTAINING THE DESIRED RESIDUAL!

EXCESS HYDROXYL ALKALINITY TO MEET RESIDUAL NEEDS.

IF OH ALKALINITY IN BOILER EXCEEDS 500 PPM (AS CACO3) THEN INVESTIGATE USE OF DEALKALIZATION, ACIDIC TREATMENT CHEMICALS, OR REDUCE CAUSTIC FOR HYDROLYSIS.

ESTIMATED REDUCTION IN NAOH (POUNDS/DAY) DUE TO NATURALLY
OCCURRING ALKALINITY = 9.65
NAOH POUNDS/DAY FOR RESIDUAL = 0.00
* NO CAUSTIC SODA REQUIRED!
CAN REDUCE EQUIVALENT CAUSTIC SODA POUNDS/DAY BY 7.48

***** DETERMINE LIGNOSULFONATE DOSAGE PER DAY *****

RESIDUAL PPM LIGNOSULFONATE DESIRED = 85.00
PURITY (%) OF LIGNOSULFONATE CHEMICAL = 100.00
LIGNOSULFONATE DOSAGE FOR RESIDUAL = 1.06
LIGNOSULFONATE DOSAGE FOR FDWTR 20 % M ALKALINITY= 0.13
LIGNOSULFONATE DOSAGE REQUIRED (POUNDS/DAY) = 1.06
ALTERNATE SLUDGE CONDITIONER USED = CPI
ACTUAL DOSAGE OF SLUDGE CONDITIONER (LB/DAY)= 8.00

***** DETERMINE SULFITE DOSAGE PER DAY *****

THE DEAERATING HEATER IS NOT BOILING PROPERLY! CHECK CALIBRATION OF THE GAUGES AND TEST THE OXYGEN CONTENT OF THE FEEDWATER.
DESIGN LIMIT PPM O2 FROM DEAERATOR NOT ACHIEVED = 0.0400

RESIDUAL SULFITE (PPM SO3) DESIRED = 49.50
PURITY (%) OF SULFITE CHEMICAL = 90.00
SODIUM SULFITE NEEDED FOR RESIDUAL = 1.08
SODIUM SULFITE NEEDED FOR OXYGEN LEAKAGE = 0.12
SODIUM SULFITE REQUIRED (POUNDS/DAY) = 1.20
ACTUAL DOSAGE OF SODIUM SULFITE (LB/DAY) = 3.05

***** DETERMINE NEUTRALIZING AMINE DOSAGE *****
***** FOR A 50/50 MIXTURE OF *****
***** CYCLOHEXYLAMINE AND MORPHOLINE *****

P ALKALINITY IN FEEDWATER BY TEST = 0.00

CALCULATED M ALKALINITY IN FEEDWATER	=	53.63
M ALKALINITY IN FEEDWATER BY TEST	=	60.00
PER CENT OF CARBONATE ALKALINITY BREAKDOWN	=	80.00
CALCULATED FEEDWATER BICARBONATE ALKALINITY	=	53.63
CALCULATED FEEDWATER CARBONATE ALKALINITY	=	0.00
EQUIV CARBON DIOXIDE (PPM CO2) IN FEEDWATER	=	42.48
PURITY (%) OF CYCLOHEXYLAMINE USED	=	60.00
PURITY (%) OF MORPHOLINE USED	=	40.00
CYCLOHEXYLAMINE DISTRIBUTION RATIO	=	9.00
MORPHOLINE DISTRIBUTION RATIO	=	0.85
CYCLOHEXYLAMINE DOSAGE (LB/DAY)	=	5.80
MORPHOLINE DOSAGE (LB/DAY)	=	8.36

NOTE THE MIXTURE RATIOS AND MAXIMUM DOSAGES ALLOWED FOR NEUTRALIZING AMINES PER AFP 91-41.

DO NOT USE AMINES IF STEAM COMES INTO DIRECT CONTACT WITH FOOD. IMMEDIATELY HAVE SERVICES PROGRAM EQUIPMENT REPLACEMENT AS THIS IS AGAINST STATED POLICY.

ACTUAL DOSAGE OF CYCLOHEXYLAMINE	(LB/DAY)=	5.71
ACTUAL DOSAGE OF MORPHOLINE	(LB/DAY)=	0.00

***** BOILER QUALITY OF INTEREST *****
***** FROM WATER TREATMENT LOG (AF FORM 1459) *****

HYDROXYL ALKALINITY	(PPM CACO3)	286.20
TOTAL DISSOLVED SOLIDS	(PPM)	1,524.70
PHOSPHATE	(PPM PO4)	48.30
SULFITE	(PPM SO3)	49.50
LIGNOSULFONATE	(PPM TANNIC ACID)	0.00
PH		11.29

TEMPER COMMENTS BELOW IF ALTERNATE CHEMICALS ARE USED VICE AFP 91-41 STOCKS.

WARNING-CALCULATIONS PREDICT EXCESSIVE SUSPENDED SOLIDS IN BOILER. INVESTIGATE HARD MAKEUP WITH NO PHOSPHATE, SOFTENING AND PHOSPHATE, AND ELIMINATION OF CONDENSATE RETURN HARDNESS CONTAMINATION!

HYDROXYL ALKALINITY OR BOILER PH IS LOW - EXPECT CORROSION AND BAD REACTIONS!

LIGNOSULFONATE OPERATING LEVEL IS LOW - MAY RESULT IN BAKED-ON SLUDGE!

WARNING-CALCULATED BOILER M ALKALINITY EXCEEDS 20% OF BOILER TDS. THIS CAUSES DETRIMENTAL FOAMING. SPLIT-STREAM SOFTEN, DEALKALIZE,OR USE SODIUM BISULFITE TO REDUCE ALKALINITY.

*** SUMMARY OF ACTUAL AND CALCULATED CHEMICAL DOSAGES ***

ANALYSIS NOTE - IF PURPOSE IS TO MODEL ACTUAL SYSTEM OPERATION, THEN DATA RECORD SHOULD REFLECT THE OPERATIONAL LIMITS BEING USED FOR EACH CHEMICAL OR TEST AND THE MAKEUP SHOULD BE CONSTRAINED TO THE ACTUAL METERED MAKEUP VALUE. THIS SHOULD RESULT IN BLOWDOWN EQUIVALENCE BETWEEN ACTUAL SYSTEM AND CALCULATED RESULTS. THEN COMPARISON OF ACTUAL AND CALCULATED DOSAGES IS OF VALUE. FOR EXAMPLE - ACTUAL SULFITE DOSAGE GREATER THAN CALCULATED COULD INDICATE MORE OXYGEN IN THE FEEDWATER THAN ESTIMATED, AN OUT OF CALIBRATION PRESSURE OR TEMPERATURE GAUGE ON THE DEAERATING HEATER, OR A DEFECTIVE DEAERATING HEATER. SIMILARLY, A HIGH PHOSPHATE DOSAGE CAN INDICATE A MALFUNCTIONING SOFTENER OR CONDENSATE CONTAMINATED WITH POTABLE WATER CONTAINING HARDNESS.

PHOSPHATE CHEMICAL USED	=	SODIUM HEXAMETAPHOSPHATE
ACTUAL PHOSPHATE DOSAGE (POUNDS/DAY)	=	3.54
CALCULATED PHOSPHATE DOSAGE (LBS/DAY)	=	2.35
ALTERNATE SLUDGE CONDITIONER USED	=	CPI
ACTUAL SLUDGE CONDITIONER (LBS/DAY)	=	8.00
CALCULATED LIGNOSULFONATE (LBS/DAY)	=	1.06
ACTUAL SODIUM SULFITE (POUNDS/DAY)	=	3.05
CALCULATED SODIUM SULFITE (LBS/DAY)	=	1.20
ACTUAL CYCLOHEXYLAMINE (POUNDS/DAY)	=	5.71
ACTUAL MORPHOLINE (POUNDS/DAY)	=	0.00
CALCULATED CYCLOHEXYLAMINE (LBS/DAY)	=	5.80
CALCULATED MORPHOLINE (LBS/DAY)	=	8.36

RUN THE BASIC ANALYSIS CALCULATIONS TO RECEIVE INTERPRETATION OF THE SYSTEM OPERATION DATA AND AN INITIAL CALCULATION OF CHEMICAL DOSAGES PER AFP 91-41. NOTE THAT AFP 91-41 ASSUMES NO STEAM OR CONDENSATE LOSSES AND ESTIMATES DAILY DOSAGES AT A HIGH LEVEL DUE TO USE OF A CYCLE OF CONCENTRATION THAT DOES NOT TAKE INTO ACCOUNT THE CHEMICALS ADDED.

Appendix Twelve

HARDCOPY OUTPUT OF ADVANCED CALCULATIONS
AND TREATMENT ANALYSIS WITH
CONSTRAINED MAKEUP AND ADJUSTED FEEDWATER OXYGEN

Note - A single row of asterisks (*) or new pages separate the screens. The screens are in order of occurrence.

ACSC/AFESC/AFIT
PROGRAM FOR STEAM BOILER WATER TREATMENT
COMPUTATION OF DAILY CHEMICAL DOSAGES
ADVANCED TREATMENT ANALYSIS

DOSAGES ARE CALCULATED ESTIMATES OF FINAL DOSAGES AT THE SYSTEM OPERATING POINT. COMPARISON WITH ACTUAL DOSAGES WILL REVEAL SYSTEM OPERATING EFFICIENCY AND TESTING ACCURACY. ADJUSTING DATA RECORDS ALLOWS COMPARATIVE ANALYSIS FOR PROPOSED SYSTEM IMPROVEMENTS OR REPAIR PROJECTS.

INSTALLATION WHERE BOILER IS LOCATED	MAXWELL AFB AL
BUILDING NUMBER WHERE BOILER LOCATED	1410
BOILER DESIGNATION	4
NAME OF PERSON MAKING THIS RUN	KAMINSKAS
COMMENT DESCRIBING THIS DATA	ACTUAL DATA-CONSTRAINED MU & CURR OPS (OXF)

***** MAKEUP WATER QUALITY OF INTEREST *****
***** AFTER ALL PRETREATMENT *****

CALCIUM HARDNESS	(PPM CACO3)	40.00
MAGNESIUM HARDNESS	(PPM CACO3)	4.00
M ALKALINITY	(PPM CACO3)	200.00
TOTAL DISSOLVED SOLIDS	(PPM)	221.00
SILICA	(PPM SIO2)	28.00
TOTAL SUSPENDED SOLIDS	(PPM)	5.00

***** CONDENSATE RETURN QUALITY OF INTEREST *****

CALCIUM HARDNESS	(PPM CACO3)	0.00
MAGNESIUM HARDNESS	(PPM CACO3)	0.00
M ALKALINITY	(PPM CACO3)	20.00
TOTAL DISSOLVED SOLIDS	(PPM)	8.00
SILICA	(PPM SIO2)	0.00
TOTAL SUSPENDED SOLIDS	(PPM)	5.00

***** DEAERATING HEATER DATA *****

OPERATING TEMPERATURE OF DEAERATING HEATER (DEG F) = 230.00
OPERATING GAUGE PRESSURE OF DEAERATING HEATER (PSIG) = 5.00
ALTITUDE OF BOILER ABOVE MEAN SEA LEVEL (FT) = 168.00
EFFLUENT OF YOUR 'DEAERATING HEATER' (PPM O2) = 0.4850

***** STEAM PRODUCTION DATA *****

OPERATING GAUGE PRESSURE OF BOILER (PSIG) = 150.00
RATED STEAM PRODUCTION OF BOILER (POUNDS/HOUR) = 22,000.00
MAXIMUM EVAPORATION (POUNDS/HOUR QSM) = 21,379.43
EVAPORATION CAPACITY INVESTIGATED (QS) = 14,399.19

***** DETERMINE OPERATING CONDITIONS *****

ESTIMATED STEAM AND CONDENSATE LOSSES (POUNDS/HOUR QL) = 2,269.23
CONDENSATE RETURNED (POUNDS/HOUR QCR) = 12,129.96

TOTAL DISSOLVED SOLIDS IN STEAM (PPM) = 0.00

SILICA IN STEAM = 0.00

MAKEUP (POUNDS/HOUR QMU) BASED ON TDS = 2,864.03
MAKEUP (POUNDS/HOUR QMU) BASED ON SIO2 = 2,787.87
MAKEUP (POUNDS/HOUR QMU) BASED ON TSS = 4,707.95

MAKEUP CONSTRAINED TO THE FOLLOWING VALUE (LB/HR) 2,994.02
WARNING-CALCULATIONS PREDICT EXCESSIVE SUSPENDED SOLIDS IN BOILER.
INVESTIGATE HARD MAKEUP WITH NO PHOSPHATE, SOFTENING AND PHOSPHATE, AND
ELIMINATION OF CONDENSATE RETURN HARDNESS CONTAMINATION!

COMPARE THIS CALCULATED MAKEUP FLOW TO THE METERED VALUE.

***** FEEDWATER QUALITY *****

FEEDWATER (POUNDS/HOUR QF) = 15,123.98

TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) = 59.04
BY CALCULATION
TOTAL DISSOLVED SOLIDS IN FEEDWATER (PPM) = 119.00
BY TEST

SILICA IN FEEDWATER (PPM SIO2) = 5.54
BY CALCULATION
SILICA IN FEEDWATER (PPM SIO2) = 6.00
BY TEST

TOTAL SUSPENDED SOLIDS IN FEEDWATER (PPM) = 5.00
BY CALCULATION

***** CYCLES OF CONCENTRATION *****

LIMIT SELECTED FOR TOTAL DISSOLVED SOLIDS (PPM) =	1,524.71
LIMIT SELECTED FOR SILICA (PPM SIO2) =	142.00
LIMIT SELECTED FOR TOTAL SUSPENDED SOLIDS (PPM) =	121.97
CYCLES BASED ON TDS - DESIGN LIMIT =	21.39
CYCLES BASED ON SILICA - DESIGN LIMIT =	27.15
CYCLES BASED ON TSS - DESIGN LIMIT =	8.92
ACTUAL CYCLES BASED ON TDS =	25.18
ACTUAL CYCLES BASED ON SILICA =	19.68
ACTUAL CYCLES BASED ON TSS =	57.01
OPERATING CYCLES OF CONCENTRATION =	20.86
CALCULATED OPERATING BOILER TDS (PPM) =	1,487.23
CALCULATED OPERATING BOILER SILICA (PPM SIO2) =	109.12
CALCULATED OPERATING BOILER TSS (PPM) =	285.05

***** DETERMINE BLOWDOWN *****

BLOWDOWN (POUNDS/HOUR QBD) =	724.79

***** DETERMINE PHOSPHATE DOSAGE PER DAY *****

CALCULATED FEEDWATER CALCIUM HARDNESS (PPM CACO3)=	7.91
FEEDWATER CALCIUM HARDNESS (PPM CACO3) BY TEST =	10.00

PHOSPHATE CHEMICAL USED SODIUM HEXAMETAPHOSPHATE

PERCENTAGE (%) OF PO4 IN PHOSPHATE CHEMICAL =	90.50

POUNDS OF SODIUM HYDROXIDE (NAOH) REQUIRED PER 100 POUNDS OF PHOSPHATE CHEMICAL = 78.4000

RESIDUAL PO4 DESIRED IN BOILER (PPM PO4) =	48.30
POUNDS OF PHOSPHATE CHEMICAL/DAY FOR RESIDUAL =	0.93
POUNDS OF PHOSPHATE CHEMICAL/DAY FOR CA HARDNESS =	1.81
TOTAL POUNDS-PHOSPHATE CHEMICAL/DAY-ADVANCED CALC=	2.74
ACTUAL DOSAGE OF PHOSPHATE CHEMICAL (LB/DAY)=	3.54

***** DETERMINE CAUSTIC SODA DOSAGE PER DAY *****

PURITY (%) OF CAUSTIC SODA USED =	98.00
NAOH POUNDS/DAY FOR PO4 HYDROLYSIS-ADVANCED CALC =	2.19
NAOH POUNDS/DAY FOR CALCIUM HYDROXYAPATITE =	0.23
CALCULATED MAGNESIUM HARDNESS IN FEEDWATER =	0.79
CALCULATED SILICA IN FEEDWATER =	5.54
SILICA IN FEEDWATER BY TEST =	6.00
SILICA NEEDED FOR MAGNESIUM REACTIONS =	1.47

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NAOH POUNDS/DAY FOR MAGNESIUM HYDROXIDE      =          0.00
NAOH POUNDS/DAY FOR SERPENTINE (MG+SILICA)   =          0.07
TOTAL NAOH POUNDS/DAY FOR MAGNESIUM REACTIONS =         0.07

SUFFICIENT SILICA FOR MAGNESIUM REACTION TO FORM SERPENTINE.

HYDROXYL RESIDUAL DESIRED   (PPM CACO3)     =        286.20
HYDROXYL RESIDUAL BY TEST                   =        286.20
BREAKDOWN OF NATURALLY OCCURRING ALKALINITY GIVES
  TOTAL ESTIMATED HYDROXYL ALKALINITY IN BOILER =    928.71
  ESTIMATED HYDROXYL ALKALINITY IN BOILER IS HEAVILY DEPENDENT ON PERCENT
  CARBONATE ALKALINITY SELECTED, USE OF NEUTRALIZING AMINES, AND REACTIONS NOT
  TAKEN INTO ACCOUNT.  ACTUAL VALUES MEASURED MAY BE AS LITTLE AS 20 PERCENT
  OF THE ABOVE ESTIMATE.
THERE IS NO HYDROXYL DEFICIENCY IN ATTAINING THE DESIRED RESIDUAL!

EXCESS HYDROXYL ALKALINITY TO MEET RESIDUAL NEEDS.

IF OH ALKALINITY IN BOILER EXCEEDS 500 PPM (AS CACO3) THEN INVESTIGATE USE OF
  DEALKALIZATION, ACIDIC TREATMENT CHEMICALS, OR REDUCE CAUSTIC FOR
  HYDROLYSIS.

ESTIMATED REDUCTION IN NAOH (POUNDS/DAY) DUE TO NATURALLY
OCCURRING ALKALINITY                        =          9.14
NAOH POUNDS/DAY FOR RESIDUAL                =          0.00
* NO CAUSTIC SODA REQUIRED!
  CAN REDUCE EQUIVALENT CAUSTIC SODA POUNDS/DAY BY      6.64

*****     DETERMINE LIGNOSULFONATE DOSAGE PER DAY    *****

RESIDUAL PPM LIGNOSULFONATE DESIRED    =      85.00
PURITY (%) OF LIGNOSULFONATE CHEMICAL  =     100.00
LIGNOSULFONATE DOSAGE FOR RESIDUAL     =       1.48
LIGNOSULFONATE DOSAGE FOR FDWTR 20 % M ALKALINITY=      0.19
LIGNOSULFONATE DOSAGE REQUIRED (POUNDS/DAY)    =       1.48
ALTERNATE SLUDGE CONDITIONER USED   =              CPI
ACTUAL DOSAGE OF SLUDGE CONDITIONER     (LB/DAY)=      8.00

*****     DETERMINE SULFITE DOSAGE PER DAY     *****

THE DEAERATING HEATER IS NOT BOILING PROPERLY!  CHECK CALIBRATION OF THE
  GAUGES AND TEST THE OXYGEN CONTENT OF THE FEEDWATER.
DESIGN LIMIT PPM O2 FROM DEAERATOR NOT ACHIEVED  =     0.4850

RESIDUAL SULFITE (PPM SO3) DESIRED     =      49.50
PURITY (%) OF SULFITE CHEMICAL         =      90.00
SODIUM SULFITE NEEDED FOR RESIDUAL        =    1.50
SODIUM SULFITE NEEDED FOR OXYGEN LEAKAGE  =    1.54
SODIUM SULFITE REQUIRED (POUNDS/DAY)      =    3.05
ACTUAL DOSAGE OF SODIUM SULFITE (LB/DAY)  =    3.05

*****     DETERMINE NEUTRALIZING AMINE DOSAGE     *****
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***** FOR A 50/50 MIXTURE OF *****
***** CYCLOHEXYLAMINE AND MORPHOLINE *****

P ALKALINITY IN FEEDWATER BY TEST	=	0.00
CALCULATED M ALKALINITY IN FEEDWATER	=	55.63
M ALKALINITY IN FEEDWATER BY TEST	=	60.00
PER CENT OF CARBONATE ALKALINITY BREAKDOWN	=	80.00
CALCULATED FEEDWATER BICARBONATE ALKALINITY	=	55.63
CALCULATED FEEDWATER CARBONATE ALKALINITY	=	0.00
EQUIV CARBON DIOXIDE (PPM CO2) IN FEEDWATER	=	44.06
PURITY (%) OF CYCLOHEXYLAMINE USED	=	60.00
PURITY (%) OF MORPHOLINE USED	=	40.00
CYCLOHEXYLAMINE DISTRIBUTION RATIO	=	9.00
MORPHOLINE DISTRIBUTION RATIO	=	0.85
CYCLOHEXYLAMINE DOSAGE (LB/DAY)	=	6.10
MORPHOLINE DOSAGE (LB/DAY)	=	8.79

NOTE THE MIXTURE RATIOS AND MAXIMUM DOSAGES ALLOWED FOR NEUTRALIZING AMINES PER AFP 91-41.

DO NOT USE AMINES IF STEAM COMES INTO DIRECT CONTACT WITH FOOD. IMMEDIATELY HAVE SERVICES PROGRAM EQUIPMENT REPLACEMENT AS THIS IS AGAINST STATED POLICY.

ACTUAL DOSAGE OF CYCLOHEXYLAMINE	(LB/DAY)=	5.71
ACTUAL DOSAGE OF MORPHOLINE	(LB/DAY)=	0.00

***** BOILER QUALITY OF INTEREST *****
***** FROM WATER TREATMENT LOG (AF FORM 1459) *****

HYDROXYL ALKALINITY	(PPM CACO3)	286.20
TOTAL DISSOLVED SOLIDS	(PPM)	1,524.70
PHOSPHATE	(PPM PO4)	48.30
SULFITE	(PPM SO3)	49.50
LIGNOSULFONATE	(PPM TANNIC ACID)	0.00
PH		11.29

TEMPER COMMENTS BELOW IF ALTERNATE CHEMICALS ARE USED VICE AFP 91-41 STOCKS.

TDS OPERATING LEVEL IS LOW - WASTE OF ENERGY AND CHEMICALS!

WARNING-CALCULATIONS PREDICT EXCESSIVE SUSPENDED SOLIDS IN BOILER.
INVESTIGATE
HARD MAKEUP WITH NO PHOSPHATE, SOFTENING AND PHOSPHATE, AND ELIMINATION OF CONDENSATE RETURN HARDNESS CONTAMINATION!

TDS ABOVE EXPECTED RANGE - MAY CAUSE DAMAGING BAKED-ON SLUDGE OR SILICA SCALE!

HYDROXYL ALKALINITY OR BOILER PH IS LOW - EXPECT CORROSION AND BAD REACTIONS!

LIGNOSULFONATE OPERATING LEVEL IS LOW - MAY RESULT IN BAKED-ON SLUDGE!

WARNING-CALCULATED BOILER M ALKALINITY EXCEEDS 20% OF BOILER TDS. THIS CAUSES DETRIMENTAL FOAMING. SPLIT-STREAM SOFTEN, DEALKALIZE,OR USE SODIUM BISULFITE TO REDUCE ALKALINITY.

*** SUMMARY OF ACTUAL AND CALCULATED CHEMICAL DOSAGES ***

ANALYSIS NOTE - IF PURPOSE IS TO MODEL ACTUAL SYSTEM OPERATION, THEN DATA RECORD SHOULD REFLECT THE OPERATIONAL LIMITS BEING USED FOR EACH CHEMICAL OR TEST AND THE MAKEUP SHOULD BE CONSTRAINED TO THE ACTUAL METERED MAKEUP VALUE. THIS SHOULD RESULT IN BLOWDOWN EQUIVALENCE BETWEEN ACTUAL SYSTEM AND CALCULATED RESULTS THEN COMPARISON OF ACTUAL AND CALCULATED DOSAGES IS OF VALUE. FOR EXAMPLE - ACTUAL SULFITE DOSAGE GREATER THAN CALCULATED COULD INDICATE MORE OXYGEN IN THE FEEDWATER THAN ESTIMATED, AN OUT OF CALIBRATION PRESSURE OR TEMPERATURE GAUGE ON THE DEAERATING HEATER, OR A DEFECTIVE DEAERATING HEATER SIMILARLY, A HIGH PHOSPHATE DOSAGE CAN INDICATE A MALFUNCTIONING SOFTENER OR CONDENSATE CONTAMINATED WITH POTABLE WATER CONTAINING HARDNESS.

PHOSPHATE CHEMICAL USED	=	SODIUM HEXAMETAPHOSPHATE
ACTUAL PHOSPHATE DOSAGE (POUNDS/DAY)	=	3.54
CALCULATED PHOSPHATE DOSAGE (LBS/DAY)	=	2.74
ALTERNATE SLUDGE CONDITIONER USED	=	CPI
ACTUAL SLUDGE CONDITIONER (LBS/DAY)	=	8.00
CALCULATED LIGNOSULFONATE (LBS/DAY)	=	1.48
ACTUAL SODIUM SULFITE (POUNDS/DAY)	=	3.05
CALCULATED SODIUM SULFITE (LBS/DAY)	=	3.05
ACTUAL CYCLOHEXYLAMINE (POUNDS/DAY)	=	5.71
ACTUAL MORPHOLINE (POUNDS/DAY)	=	0.00
CALCULATED CYCLOHEXYLAMINE (LBS/DAY)	=	6.10
CALCULATED MORPHOLINE (LBS/DAY)	=	8.79

RUN THE BASIC ANALYSIS CALCULATIONS TO RECEIVE INTERPRETATION OF THE SYSTEM OPERATION DATA AND AN INITIAL CALCULATION OF CHEMICAL DOSAGES PER AFP 91-41. NOTE THAT AFP 91-41 ASSUMES NO STEAM OR CONDENSATE LOSSES AND ESTIMATES DAILY DOSAGES AT A HIGH LEVEL DUE TO USE OF A CYCLE OF CONCENTRATION THAT DOES NOT TAKE INTO ACCOUNT THE CHEMICALS ADDED.

END

DATE

FILMED

8-88

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